Interaction Between Groundwater and Surface Water Regimes and Mining-Induced Acid Mine Drainage in the Stockett-Sand Coulee Coal Field

TECHNICAL COMPLETION REPORT

Interaction Between Groundwater and Surface Water Regimes and Mining-Induced Acid Mine Drainage in the Stockett-Sand Coulee Coal Field

Project A-129MONT

to

Montana Joint Water Resources Research Center
Montana State University
Bozeman, Montana 59715

and

Montana Department of State Lands
Helena, Montana

by

Thomas J. Osborne
Joseph J. Donovan
John L. Sonderegger

Montana Bureau of Mines and Geology
Montana College of Mineral Science and Technology
Butte, Montana 59701

June 1, 1983

The work upon which this report is based was supported by funds provided by the Department of the Interior as authorized under the Water Resource and Development Act of 1978, P.L. 95-467, by the Montana Department of State Lands and by the Montana Bureau of Mines and Geology.

ABSTRACT

Abandoned underground coal mines in the Stockett and Sand Coulee, Montana region have been discharging acid water for many years, causing severe pollution of Sand Coulee Creek and tributaries, and ground-water resources. A two-year investigation of the hydrogeology of the Sand Coulee Creek basin was conducted to formulate acid mine drainage mitigation techniques base on hydrologic systems controls and de-centralized neutralization.

Periodic field inventories in 1980-83 located at least 17 acid discharge points flowing either perennially or ephemerally. The measured total rate of acid discharge ranged from 1-3.3 ft^3/s. Most acid discharges were of very poor quality with field pH ranging from 2.2 to 5.4, acidity from 108 to 6002 mg/l as $CaCo_3$ and specific conductance from 1038 to 15,966 microsiemens per centimeter. Water types were mostly ferrous-allumimum sulfate with dissolved iron concentrations from 12 to 1065 mg/l.

Two stream gaging stations were installed on Sand Coulee Creek and one on Straight Creek. Although the watershed area of Straight Creek is only 4% that of Sand Coulee Creek, it had longer duration and sometimes greater magnitude baseflow, primarily composed of acid mine drainage. Acid water comprises roughly 60-90 % of the baseflow of Sand Coulee Creek. Most baseflow is lost to evapotranspiration and subsurface seepage.

A regional inventory of 46 domestic wells indicated that approximately one-half utilized the Madison Limestone aquifer as the primary water source with most of the remainder equally divided between Kooten-

ai sandstone and Jurassic sandstone aquifers. Most alluvial ground water is polluted and has not been utilized by residents for many years. Vertical ground-water gradients are primarily downward which has allowed mine drainage contamination to reach the Jurassic and Madison aquifers. Water quality analyses and chemical modeling indicated the probable contamination of seven of sixteen sampled wells in these aquifers. Mine drainage water reaches lower bedrock aquifers through stream seepage, alluvial ground-water leakage and well bore leakage.

Proposed mitigation techniques included, infiltration control through cultivation of water consumptive crops and grain re-cropping in recharge areas, vertical connector wells or horizontal wells to dewater the Kootenai aquifer overlying the old coal mines, injection and neutralization of acid water in the Madison limestone and small-scale neutralization pits using flyash and alkaline Kootenai ground water.

Key words: Acid mine drainage, streamflow seepage, surface water-ground-water interaction, ground-water contamination, infiltration control, drainage wells.

ACKNOWLEDGEMENTS

The authors wish to thank the residents of the Stockett and Sand Coulee, Montana area for their assistance and support of this investigation.

Credit for technical support and field data collection go to Art Middelstadt, MBMG hydro-technician, and Montana Tech students Herman Moore, Walter Benjamin, Kim Knerr, Joe McElroy.

Page

TABLES

FIGURES

APPENDICES

1. INTRODUCTION

This report presents results of the Montana Water Resources Research Center project no. A-129MONT, Interaction between ground water and surface water regimes and mining-induced acid mine drainage (AMD) in the Stockett-Sand Coulee Coal Field. The second year of the project was 50% funded by the Montana Department of State Lands, Helena, Montana. The project was conducted by the Montana Bureau of Mines and Geology, Butte, Montana in 1981-83.

1.1 Problem Description

Coal in the Stockett-Sand Coulee area, near Great Falls, Montana, occurs within the upper part of the Morrison Formation (Jurassic) and is exposed along outcrops in the valley of Sand Coulee Creek and its tributaries. Unlike the Eastern Montana Tertiary coal deposits, the coal in this area is higher in grade (bituminous) as well as in sulfur content (0.5-5.5%) and is moderately high in ash (about 20%) (Silverman and Harris, 1967). Mining in the area commenced before the turn of the century via numerous adits which were constructed along the bottoms and sides of the major coulees. The last large-scale mine closed in 1952, but some recent exploratory drilling has been concentrated in the area between Great Falls and Stanford, where these coal deposits occur generally within 100-300 feet of land surface.

The extensive underground mining activity has allowed easy access for oxygen and water to enter the system of abandoned mines, and as a result, the area now has an extensive acid mine drainage problem. Ground water infiltrates through the overlying Kootenai Formation into the Morrison Formation, oxidizing pyrite within the abandoned mines and

discharging at low pH (2.3-5.0) from abandoned mine portals or through mine spoil backfill materials.

While the existing problem is primarily the result of mining activities, it is possibly being enhanced by non-water conservative summer-fallow cropping practices on the upland benches, which increase the amount of water that moves into the subsoil and then into the Kootenai Formation. Any future mining operations which become active in this area will have to confront the hydrologic impacts of their activities during and after mining. In light of the proposed construction of coal-fired generating facilities in the Great Falls area within 20 miles of this old mining district, the probability of new mines being established somewhere in the Great Falls-Lewistown coalfield, although remote, is as great as it has been in the last 30 years. A location map is shown in Figure 1.

1.2 Previous Work

Fisher (1909) published the first report on this area, describing the geology and coal resources in some detail and including a brief description of the mining operations active at that time. A chemical analysis of spring water near Stockett was made, which indicated that the water was alkaline and unpolluted.

Goers (1964) performed a geological study of the Stockett-Smith River area, which included field inventory of a number of water wells in this area.

Silverman and Harris (1967) described the geology and stratigraphy of the Great Falls-Lewistown Cretaceous coal field. A generalized stratigraphy and detailed isopachs of coal sequence were presented.

Also, geochemical characterization of a limited number of coal samples was performed.

McArthur (1970) performed a detailed short-term study of the environmental aspects of acid mine drainage in the Stockett-Sand Coulee area. He performed a detailed spring inventory and measured flows and pH over an eight month period for selected springs and surface-water stations. His work included an assessment of the hydrologic system, some water quality analyses and presentation of some alternatives for mine water neutralization, including limestone or lime treatment and mine flooding.

Hydrometrics (1982) submitted an extensive and comprehensive report on abandoned mine lands in the Belt-Sand Coulee area, concentrating on, but not limited to, the hydrology of acid mine water in this area. They provided a complete literature review, an assessment of amelioration alternatives and a re-inventory of the springs in this area. Some hydrologic data was collected, although only over a four month period.

1.3 Study Rationale

This project was designed to collect sufficient data to allow assessment of alternatives to centralized treatment of acid mine drainage. An ideal alternative to treatment would dispose of and/or prevent acid mine discharge in an inexpensive manner, easily applied over an extensive area, with reasonable maintenance. This investigation focused on the hydrogeologic background of two general amelioration techniques which may meet these criteria:

1) Infiltration control; whereby the amount of water infiltrating the old mine workings is reduced by minimizing ground-water recharge or dewatering the overlying aquifer; and
2) On-site neutralization methods involving surface neutralization of the numerous small acid seeps in small ponds or by gravity injection and neutralization of acid water within the underlying limestone of the Madison group rocks.

1.4 Project Objectives

Project objectives for the first year of study (FY 81) were as follows:

1) Initiation of a comprehensive inventory of all springs and water wells in the study area, including a re-inventory of springs recorded by McArthur (1970);
2) Establishment of 1-3 permanent stream gaging stations in the Sand Coulee drainage, including Straight (No-Name) Creek;
3) Initial monitoring of springs in the area for flow, pH and specific conductance;
4) Water quality analysis, to characterize ground- and surface-water quality and to support investigation of their interaction.

Project objectives in the second year included:

1) Continuation of acid discharge monitoring;
2) Streamflow monitoring via the gaging stations and seepage runs;
3) Completion of a comprehensive domestic well inventory, aquifer identification, static water levels and field water quality characteristics;

4) Collection and analyses of ground-water quality data;

5) Preparation of a proposal for implementation of AMD mitigation techniques using hydrologic systems controls.

1.5 Study Site Reference System

All springs and streamflow stations were numbered using an arbitrary sequential reference system, organized by drainage basin. Acid discharge reference codes used in this and previous investigations are shown in Table 1.

Straight Creek, as it is called by local residents, is not named as such on the U.S. Geological Survey (USGS) quadrangle map, but refers to the drainage through the town of Sand Coulee that is tributary to Sand Coulee Creek. This drainage is referred to by McArthur (1970) as "No-Name Creek".

Hereafter, the term "study area" is used to refer to the drainage area of Sand Coulee Creek from its headwaters to a point about two miles north of Tracy, Montana, where the creek enters the abandoned Missouri River channel. The principal towns of the study area are from north to south, Tracy, Sand Coulee, Centerville and Stockett, shown in Figure 1.

2. RESULTS

2.1 Springs

2.1.1 Spring Inventory and Monitoring

During the first year of the project, 17 springs were found to be discharging acid water from mine portals or spoil piles either perennially or intermittently (Figure 2). Nine springs flowed perennially,

while eight flowed only during or after spring precipitation and snowmelt periods. These springs in general corresponded to those observed by McArthur (1970) to be active in 1969. Five springs which flowed in 1969 (McArthur's 36-3, 36-6, 7-8, 7-9 and 18-5) were not observed to flow in 1980-81. Another seep in a spoil pile (13-2) found by McArthur has apparently become plugged in recent years. A large seep area near the old Giffen mine was not included in MacArthur's inventory, possibly because the pH is not below 4 at all times of the year.

Table 2 describes the active springs; ranges of flow, conductance and pH.

These springs were monitored on a periodic basis, to evaluate annual variability in flow and water quality. The results are included in Appendix A. During the period from 6-1-80 through December 1981, results for the monitoring may not be representative of the average year. The winters of both 1979-80 and 1980-81 were very dry in the study area, despite ensuing wet spring seasons. However, the patterns of variability and response of the acid springs to precipitation events are probably typical. The net discharges of acid mine water for this two-year period may be slightly below the long-term average.

Based on the monitoring to date, the acid springs can, with several exceptions, be separated into two arbitrary groups. The first group consists of springs with high flow variability (those which have a ratio of high flow to low flow greater than 5 and very rapid response to major springtime precipitation or snowmelt events, usually responding within a few days). These springs are usually associated with mine adits located less than 150 vertical feet below the top of the overlying bench. The second group also exhibits springtime increases in

flow but to a much lesser degree. These adits are located a greater vertical distance from the adjacent uplands where the ground-water flow system is recharged.

Springs in the first group (variable discharge) are in all cases located north of the town of Stockett, including the springs near the towns of Sand Coulee and Centerville. Some of these springs with exceptionally high variability include AS-01 (from 43-500 gallons per minute (gpm)), AS-07 (from 12.5-250 gpm) and CS-10 (from 0-80 gpm). In May 1981, peak flows at springs were obtained within two weeks of the end of the period of most intense precipitation. The pH in springs of the first group ranges from 2.29-4.20, with most in the range 2.3-2.9. Most springs (AS-03, AS-02, AS-04, AS-01, AS-07) tend to become only slightly more alkaline during high flow periods in the spring, probably due to dilution by alkaline recharge. Others (AS-06, CS-10) become more acid, probably due to flushing of pockets of stagnant water of high acidity from the mines due to an increased flow caused by infiltration on the upland benches. Recharge water infiltrating into the mines must not be of sufficiently high alkalinity or volume to reduce the acidity of the discharge.

Figure 3 shows spring discharge measured on 5/28/81, immediately after intense spring rains. The flows are, in all cases, the highest observed for each acid spring during 1980-1981 and in some cases represented an order of magnitude increase over discharge at low flow. Actively discharging acid springs are common along the west side of the upland bench separating Straight Creek from Sand Coulee Creek and are east of this bench relatively scarce in the Centerville area. This suggests that the springs in the town of Sand Coulee are locally re-

charged and that ground water flows in these mines to the northwest, possibly conforming to the dip of the Morrison and Kootenai beds beneath this bench. The total measured acid discharge from all springs was a minimum of about 358 gpm (0.8 ft^3/s) on 3-5-81 and a maximum of about 1479 gpm (3.3 ft^3/s) on 5-28-81.

Specific conductance (S.C.) values of mine discharge (Figure 4), taken at the same date, are in most cases not greatly lower than at other times of the year and in several springs is actually higher than at low flow. S.C. ranges from 476-10,306 microsiemens per centimeter (us/cm), with the springs discharging water of less than 1000 us/cm being either alkaline or dominated by alkaline recharge. Most spring discharges are in the range from 2000-7000 us/cm. Dissolved ferrous iron concentrations and concentrations of suspended ferric hydroxide have a large influence on the S.C. of these waters, and for this reason S.C. is probably less indicative of other water quality characteristics than it is for most natural waters. Spatial patterns are not apparent in this S.C. data, but generally springs which emit from backfilled minespoil materials are of poorer water quality and higher conductance than those discharging from open adits.

Specific conductance variations indicate that, despite the large increases in flow in the spring, very little dilution by recharge water is taking place. Most conductance values decreased by less than 25% in May 1981, in response to over 6 inches (in.) of local precipitation. Several springs (AS-06, AS-07) actually increased in conductance, suggesting again that isolated pockets of poor quality water in the mines are being flushed in the spring and lie stagnant during much of the rest of the year.

The very rapid hydrologic response of most acid springs suggests substantial interconnection between the surface and the mine workings, probably along vertical joints and fractures sometimes visible along valley walls. The morphology of stream and coulee orientations in the region suggests structural control which may be another expression of this joint system.

Several open adits were found in the bottom of Mining Coulee, south of Sand Coulee, where high water marks indicated that large volumes of surface runoff pour directly into the old mine workings. The rapid response of AS-01, in particular, may be related to this apparent surface water infusion.

From well records, saturated sandstone strata occur throughout the Kootenai Formation although only the basal sandstone unit shows extensive continuity and saturation. Recharge along fractures may increase the pressure head within these beds and augment the rate of leakage from these perched aquifers through fractures into the underlying basal Kootenai. The conglomeratic sandstone unit at the base of the Kootenai probably forms the roof of many of the mine adits and is the primary source of ground-water leakage into the old workings.

Increase of seepage rates from the basal Kootenai into the mines increases ponding of water within the mines and flushes pools of acid mineralized water towards the portals. Due to the slope of the adits, they drain freely and oxygen has ready access, allowing pyrite oxidation to occur at a high rate.

The recharge-discharge relationship for most acid springs is believed to be quite local. For example if the mean annual flow rate from AS01, AS02, AS03 and AS07 is estimated to equal 300 gpm (0.668

cubic feet per second (ft^3/s)), assuming the approximately 3 square miles (mi^2) bench area south of Sand Coulee to be the recharge area, the annual recharge rate would equal 3 in. This represents about 19% of the mean annual precipitation, a reasonable estimate for this area.

Only a few springs fall into the second, low-variability category. They include CS-09, along Cottonwood Coulee two miles south of Stockett, and BS-01, the Giffen Mine East outflow. Both occur at elevations nearly 200 feet below the surrounding upland benches where ground water is recharged. This additional separation from recharge apparently dampens the spring response to rainfall and snowmelt infiltration. The Giffen Spring increased in flow by a factor of about 1.5 in May 1981; its water quality decreased considerably, with pH decreasing more than a whole unit and conductance increasing from 6000 to 8600. During fall and winter, at low flow, both pH and water quality improve somewhat.

The Giffen Spring (BS-01) produces relatively consistent baseflow, averaging 250 gpm (3040 acre-feet/year) during the 1981 water year. Local precipitation was probably slightly higher than the local average of 15 in./year, although no accurate precipitation data are available from this specific locality. Assuming 16 in. total for the year and assuming, quite liberally, that 50% (8 in.) of this precipitation contributed to ground water as infiltration rather than contributing to crop use, runoff, or evapotranspiration, then discharge from these mine workings was recharged from an area at least as big as 7.12 $mi.^2$, an area greater than the 3-4 $mi.^2$ available for recharge along the upland bench immediately to the east of the mine. It is probable that groundwater flow in the Kootenai moving down gradient from its recharge area towards the Belt Mountain foothills is being intercepted by the old

mine workings and discharging from the north-westerly sloping Giffin adit.

2.1.2 Spring Water Quality

Water quality data collected from springs in 1980 and 1981 are listed in Appendix A (A-2). Field pH for spring waters ranges from 2.38-3.98 for all sites except BS-01, the Giffen mine, where it ranges from 3.8-5.4. While none of these springs are alkaline, acidity shows a broad range, from 108 (BS-01) to 6002 (AS-03) milligrams per liter (mg/L) as $CaCO_3$. The waters are ferrous-aluminum-sulfate dominant, with minor calcium and magnesium. Iron (Fe) (12-1065 mg/L) and aluminum (Al) (1.72-752 mg/L) are the most abundant metals, although there are also high concentrations of trace metals including nickel (Ni) (0.24-5.31 mg/L) and zinc (Zn) (0.60-21.5 mg/L). Lesser (<1 mg/L) but detectable concentrations of cadmium (Cd), chromium (Cr), copper (Cu), and in some cases molybdenum (Mo) also occur. Both arsenic (As) (<80 parts per billion (ppb)) and selenium (Se) (<21 ppb) are at low concentrations.

Ferrous iron is dominant over ferric at the mine mouths, although some minor amounts of iron in excess or dissolved iron were recovered--probably ferric hydroxides in suspension in the water. $FeSO_4^o$, $AlSO_4^+$, and $Al(SO_4)_2^-$ are all strong complexes in this solution. Sulfate activities are probably at a plateau in some of these waters, due to the fact that the majority of any sulfate added to the water is probably complexed by either iron, aluminum, or alkaline earths and many waters are saturated with respect to gypsum. As the iron oxidizes and drops out of solution downstream, the sulfate activities might be

expected to increase and possibly cause other sulfate species to attain saturation.

These waters are undersaturated with respect to all but a few mineral phases. One is gypsum; another is chalcedony, which becomes supersaturated in neutralized waters due to dissolution of silicates under acid conditions.

2.2 Ground Water

Ground water occurs in most all of the permeable rock units in the Stockett-Sand Coulee area. A description of the geologic formations in the area is given in Appendix B. From oldest to youngest age, aquifers are known to yield water to wells from the Mission Canyon formation of the Madison Group (Mississippian), the Swift Sandstone (Jurassic), sandstone beds in the lower Kootenai formation (Lower Cretaceous), glacio-fluvial and glacio-lacustrine deposits (Quaternary) and stream alluvium (Quaternary). Figure 5 is a schematic hydrogeologic section. Vertically stacked aquifers separated by shale aquitards frequently occur, and surface water-ground water interaction is a common phenomenon. Ground water movement is primarily horizontal within specific aquifers, in response to the hydraulic gradient. Vertical movement of ground water can occur when two aquifers are in direct contact with each other, when natural rock fractures or man-made features such as well bores allow vertical movement, or by slow leakage through aquitards.

An inventory of domestic water wells in the study area was completed in summer 1982. Field data are presented in Appendix C (C-1) and included owner, location, static water level, field specific con-

ductance and pH and water use information. Measured static water levels, and S.C.'s are shown in Table 4 and are referenced to a location map in Figure 6. Field data were correlated with the Montana Ground Water Appropriation forms which gave useful information on well completion, yield and the lithology encountered in drilling. A total of 46 domestic wells were inventoried on at least one occasion. The Madison limestone aquifer supplied 24 wells, Jurassic sandstones 11, Kootenai sandstones 10, and alluvium only 2. Five wells were completed in multiple aquifers and the water bearing source of two wells could not be estimated at all.

2.2.1 Madison Aquifer

The Mission Canyon Formation of Mississippian Age is the principal aquifer in the Madison Group Rocks. It is composed of massive light-gray limestone and thin dolomite interbeds which have been extensively karstified. Ground water flows through fractures and solution cavities that may occur from near ground surface to depths of at least 700 feet. The aquifer appears unconfined to moderately confined in the study area based on water level data, and some Madison wells in the Centerville and Tracy area expel and suck air with considerable force. Horizontal ground-water flow is generally from south to north (Feltis, 1980, 2). Vertical ground-water flow in the study area is downward with some deeper Madison wells having lower static water levels than shallower ones.

The primary recharge area for the Madison aquifer is on the flanks of the Little Belt Mountains where many square miles of Madison Group rocks are exposed to relatively high precipitation (20 in. or more

annually). Additionally, streams are reported to lose water as they traverse portions of the Madison outcrop. More limited recharge occurs in the study area where local doming of the Madison results in exposures of fractured limestone in the Centerville-Stockett area. Streamflow from Number Five Coulee and Cottonwood Coulee directly infiltrates Madison rocks. The Madison also probably receives recharge as leakage from overlying saturated alluvium. Results of water quality analyses indicates that some of this recharge is acid mine drainage water.

The best known discharge point for the Madison aquifer is Giant Springs just east of the city of Great Falls. Approximately 300 ft^3/s of ground water issues from large springs near and in the Missouri River (Patton, 1983). Between Tracy and Great Falls, the Madison aquifer may develop upward vertical leakage and discharge to overlying aquifers and to the pre-glacial Missouri River Channel south of Great Falls. Water quality and head data from the Madison, Swift and Kootenai aquifers is often similar, suggesting a high degree of interaquifer connectivity just north of the study area.

2.2.2 Swift Aquifer

The Madison Group is unconformably overlain by Jurassic marine sediments of the Ellis Group. Sandstone of the Swift Formation directly overlays the Mission Canyon Formation in much of the study area. The Swift is a fine- to medium-grained, well-cemented quartz sandstone from 0-40 feet thick. It appears cross-bedded or massive in outcrop, weathering to a pale orange to brown color. Beds of chert-pebble and brachiopod shell hash conglomerate may occur in the lower part. The Swift occurs over most of the study area and is well exposed

in the coulee bottoms of Cottonwood Creek north of Stockett and Number Five Coulee southwest of Stockett.

The Swift sandstone is known to yield water to three wells in the Tracy vicinity south of Stockett, and it is the probable source of two springs issuing near the bottom of Cottonwood Creek below the Morrison coal seam. Relatively little is known concerning the extent, thickness and water-yielding characteristics of the Swift sandstone between Stockett and Tracy. In the Sand Coulee Creek Valley north of Centerville, water wells drilled to the Madison sometimes do not encounter the Swift sandstone, indicating it is probably removed by erosion. One Swift well just northwest of Tracy was sampled and has a TDS of 1,994 mg/l, indicating potential contamination from AMD in nearby Sand Coulee Creek. Data are too sparse to construct a potentiometric map of the Swift, although flow is believed to occur from south to north.

The recharge-discharge regime of the Swift aquifer is not well known. Like the Madison, it is probably recharged where exposed along the flanks of the Little Belt Mountains and to a lesser extent in the study area, where local doming and erosion in coulees bring the ground surface close to the elevation of the Swift Sandstone. Since there is no observable confining bed between the Swift and Madison aquifers, they may act as a unit north of Tracy where the Madison becomes fully saturated. Similar heads and water quality between Tracy and Great Falls further suggest the inter-connectivity of the Madison and Swift aquifers.

The Swift Formation is overlain by the Morrison Formation which consists of 100-200 feet of gray shale with interbedded sandstone, limestone and coal. The Morrison coal bed or beds occur near the top

of the Jurassic section and were the target of mining in the area.

2.2.3 Kootenai Aquifer

The Lower Cretaceous freshwater Kootenai Formation is present at land surface over most of the study area and unconformably overlays the Morrison Formation. The basal unit of the Kootenai is a resistant, cross-bedded, coarse, salt and pepper sandstone bed, from 2-80 feet thick (Walker, 1974). Above this basal sandstone, the Kootenai consists of numerous, lensaic, poorly continuous sandstone beds, 1-50 feet thick, interbedded with green, gray and maroon mudstone. The Kootenai is typically 100-300 feet thick in the study area with 100-300 feet of the upper Kootenai member having been removed by erosion. The basal conglomeratic sandstone unit directly overlays the Morrison coal bed and is a relatively continuous aquifer supplying wells throughout the study area. More discontinuous sandstone beds occur stratigraphically higher on the Kootenai and occasionally yield water to wells and springs.

Horizontal ground-water flow in the basal Kootenai aquifer is generally from the topographically high benchlands to nearby coulees bisecting the Kootenai formation. There is a regional bedrock dip of approximately 3-6 degrees to the north-northwest and ground water migrates down dip, commonly resulting in springs and seeps on the northwest terminus of benches. Southern and eastern Kootenai outcrops are usually drier. In unmined areas, natural springs are common at the contact of the basal Kootenai with the less permeable Morrison Formation.

The many thin sandstone and shale beds in the Kootenai are quite

brittle and flexure of the South Arch in Tertiary time resulted in extensive fracturing of the Kootenai rocks. These fractures and related joint systems readily allow vertical ground-water movement and recharge from surface sources. The limited data available from domestic wells indicates that the basal Kootenai aquifer is sometimes confined in the middle of benches, and is frequently unconfined in wells near the edge of benches where the Kootenai section is bisected.

In relation to acid mine drainage, the removal of the coal bed underlying the basal Kootenai sandstone aquifer has resulted in leakage of ground water into the old mine workings. The old tunnels and rooms are efficient ground-water drains, which locally dewater the basal Kootenai sandstone and allow water to be conveyed down-gradient to old mine portals situated at the outcrop areas in the principal coulees. The normally alkaline Kootenai ground water is exposed to atmospheric oxygen and pyrite in the old mines where the chemical oxidation process occurs, producing AMD.

2.2.4 Quaternary Aquifers

Ground water occurs in stream alluvium deposits of Sand Coulee Creek and tributaries in the study area. These deposits are relatively thin south of Sand Coulee and Centerville, typically 10 to 30 feet thick. North of these towns, the valleys of Sand Coulee Creek have been filled with a combination of alluvial, glacial, and lacustrine deposits to thicknesses of up to 150 feet as recorded by water well drillers. The alluvial deposits are typically sand and fine-medium size gravel, gravelly clay, sandy loam, and sandy clay, brown to yellow-brown in color.

Evidence of glacial and lacustrine deposits comes from the widespread influence of Pleistocene continental glaciation throughout the Great Falls area as described by Alden (1932) and Walker (1974). Several water well logs in the Tracy vicinity record alternating deposits of yellow, sandy clay and gray silt, consistent with a postulated sequence of glacial deposits and lacustrine deposits from ice-marginal glacial lakes.

Water wells in the abandoned pre-glacial Missouri River Valley north of the study area are reported to obtain good yields of ground water from scattered sand and gravel lenses (Walker, 1974). But the lateral occurrence and depth of these deposits are unpredictable. Wilke (1983) inventoried at least 5 water wells completed in Quaternary deposits found in the pre-glacial channel.

Although most of the alluvial deposits in the study area are saturated, little use is currently made of alluvial ground water due to AMD contamination. Only south of Stockett, above the highest elevation AMD source, is significant use made of alluvial ground water. The town of Stockett obtains a portion of its water supply from an alluvial infiltration gallery about 2 miles south of town. However, local residents report high iron problems occur in the spring when ephemeral AMD sources discharge upgradient from the collector.

The alluvial deposits of Sand Coulee Creek and tributaries are the intermediate receptor of most visible AMD in the study area. Stream channels cut into the alluvium carry most of the AMD discharge. However, in the Sand Coulee and Centerville vicinity, as the alluvial deposits deepen, streamflow is partially or entirely lost to the alluvium. AMD is therefore a continued source of recharge to the alluvium.

North of Tracy, the alluvium is apparently in direct contact with the Madison limestone. Reports from drillers indicate that the vertical gradient is downward, thereby allowing AMD contaminated alluvial ground water to recharge the Madison aquifer. Local residents also report that the acid alluvial ground water has caused failures of cement grout and steel casing in the alluvium and that downward leaking alluvial ground water has contaminated formerly good quality Madison aquifer ground water.

2.2.3 Ground Water Quality

The chemical quality of ground water in the Stockett-Sand Coulee area is quite variable due to the different types of rocks comprising the multiple aquifers, the effects of AMD, the hydraulic connections between aquifers and surface water-ground water interactions.

In general, it is possible to discuss each aquifer as having its own "characteristic" water quality and intra-aquifer trends. Variations from the typical condition are most often due to inter-aquifer mixing or to chemical reactions imparted by acid mine drainage water. Water quality data from laboratory analyses of sampled wells are presented in Appendix C (C-2).

2.2.5.1 Madison Aquifer

Water wells tapping the Madison aquifer southeast of the Missouri River near Great Falls usually have total dissolved solids (TDS, calculated) concentrations usually in the range of 400-600 mg/l. Giant Springs, several miles northeast of Great Falls, is thought to be a regional discharge point for the Madison aquifer. The spring has been

sampled 11 times between 1890 and 1983 and has had a TDS of 369 to 498 mg/l and approximately equal milliequivalence of Ca^{2+}, Mg^{2+}, HCO_3, and SO_4^{2-} (Patton, 1983). Feltis (1980, 1) mapped TDS concentrations of Madison wells throughout northern Montana which showed a concentration gradient of less than 1000 mg/l near mountain uplifts to over 10,000 mg/l in the Williston basin. The density of wells sampled, however, except in the Great Falls and oil field areas, is quite low.

The chemical quality of Madison wells sampled in the Sand Coulee area is quite variable and does not fit expected patterns. Figure 7 is a histogram indicating that seven of twelve Madison samples were less than 600 mg/l, and five ranged from 600 to 2,413 mg/l. The five high TDS samples had milliequivalent ratios of sulfate to bicarbonate of from 1.7 to 7.7. Figure 8 is a Piper plot which graphically illustrates the progression of increased sulfate concentrations among the samples. An analysis of Giants Springs is included for comparison.

Since the high TDS wells are scattered throughout the study area, there is little evidence to support a water quality trend of this magnitude based on length of ground-water flow path. Anhydrite beds known to occur in the Charles Formation which, in places, overlies the Mission Canyon Formation, could be a source of sulfate and TDS increases. However, the Charles Formation is not known to occur in this area and lithologic logs of water-well drillers have not indicated any evaporitic zones in the study area.

Although natural sources cannot entirely be ruled out, at this time a plausible explanation for the anamalously high TDS and sulfate concentrations is the infiltration and mixing of AMD water with native Madison aquifer ground water. Higher TDS and sulfate concentrations

are a byproduct of the acid producing metal oxidation reactions that take place in the old mines and during surface water or ground-water transport of AMD. It is believed that the contaminated Madison wells are generally down-gradient from an AMD source, particularly if the well is in a tributary coulee bottom. The downward gradient and possible fractures associated with the coulee may provide the conditions favorable for contamination. Figure C-3 (Appendix C) shows the proximity of AMD sources to the Madison aquifer wells in the study area. Chemical models of the AMD and Madison ground-water interaction are presented in section 3.3.

2.2.5.2 Jurassic Aquifers

The Swift Formation is the most prevalent Jurassic aquifer in the study area, however, other water-bearing sandstones occur regionally in the Morrison Formation which overlies the Swift sandstone. Four Jurassic aquifer samples were collected in this investigation but lack of well log information prevented differentiating the specific water-bearing zones.

Three of the Jurassic aquifer samples are calcium-magnesium-bicarbonate types with TDS of 277 to 433 mg/l, and one, the Lyman well, is a calcium-magnesium-sulfate type, with a TDS of 1737 mg/l. The analyses are plotted on a Piper diagram in Figure 9.

Wilke (1983) reported analyses from three Morrison wells and two Swift wells in the Great Falls vicinity. Morrison wells had TDS (sum of constituents) range of 908-1480 mg/l and had mixed water types. The Swift wells had TDS values of 846 and 1020 mg/l and were calcium-sulfate and sodium-sulfate water types respectively.

The proximity and hydraulic connectivity of Swift and Morrison aquifers to each other and to adjacent aquifers may give reason to expect water quality variability. The Lyman well appears anamolously high in TDS and sulfate and may be affected by AMD water. No log exists for the well but it is drilled on the very edge of the Sand Coulee Creek Valley which is known to be a source of AMD leakage to lower bedrock aquifers.

2.2.5.3 Kootenai Aquifer

The Kootenai aquifer is the surficial bedrock aquifer over most of the study area and receives recharge directly from precipitation and surface sources. Four water samples from the Kootenai aquifer were collected in this investigation.

Three samples were collected from the basal Kootenai sandstone aquifer, two from wells and one from a spring. The two well samples had TDS values of 369 and 433 mg/l and were a magnesium-bicarbonate type. The spring was located about 400 meters north of the Giffen mine works and had a TDS of 295 mg/l, and was a calcium-magnesium-bicarbonate type.

One sample came from a well also near the Giffen mine but located on the bench. The water-bearing zone was a limey sandstone about 65 feet below ground surface and about 50 feet above the basal Kootenai sandstone. The TDS was 369 mg/l and it was a calcium-magnesium-bicarbonate type. The analyses are plotted along with the Jurassic well samples on a Piper diagram in Figure 9.

These results are similar to those of Wilke (1983) who sampled five Kootenai wells in the Great Falls vicinity and reported a TDS

range of 558 to 1,550 mg/l, with magnesium and bicarbonate being the principal constituents in three of the samples.

Total field alkalinity in the Kootenai samples ranged from 269 to 433 mg/l as $CaCO_3$ and field pH ranged from 6.63 to 7.48. Kootenai aquifer ground water is thought to be the principal source of leakage into old mine workings and hence is the water that becomes acidized. These analyses indicate that native Kootenai ground water is alkaline and of relatively good quality. The undisturbed Morrison coal bed is thought to be an aquitard and hence does not transmit appreciable quantities of ground water.

2.2.5.4 Quaternary Aquifers

The alluvial valleys of Sand Coulee Creek and tributaries contain ground water, although in most of the study area, it is not used domestically because of AMD contamination. Residents long ago abandoned alluvial wells and consequently there are very few existing alluvial wells. No alluvial wells could be found north of Stockett, and so no data could be collected on alluvial water quality.

The town of Stockett's alluvial collector well 2.5 miles south of Stockett was field checked in spring, 1981 and found to have a pH of 5.3. The alluvium there is up-gradient from most perennial AMD discharges, however, ephemeral AMD sources apparently discharge during wet weather, causing some seasonal contamination. Stockett residents complained of iron staining and bad taste during these occasions and in 1981 drilled a deep well to the Madison aquifer for a public supply. This has been the trend throughout the study area. Shallow alluvial wells have been replaced by deeper bedrock wells to escape AMD contam-

ination problems. However, as previously indicated, both Jurassic and Madison aquifers show evidence of contamination in selected wells.

Further suggestion of alluvial ground-water contamination came from rancher O. G. Johnson who lives about 2 miles north of Tracy. He reports that a number of shallow wells drilled across his property in Section 31 (T. 20 N., R. 5 E.) and Section 6 (T. 19 N., R. 5 E.) encountered only AMD affected water. As a result, they drilled deeper wells to the Madison aquifer but in at least one case, acid water disintegrated the cement grout and steel casing causing the well to be contaminated and abandoned.

Contamination of alluvial ground water may extend along the entire reach of the pre-glacial Missouri River, now occupied by Sand Coulee Creek. The extent of contamination will be mapped in a subsequent investigation by the MBMG and Montana Department of State Lands.

2.3 SURFACE WATER

2.3.1 Gaging Stations

Three gaging stations were installed within the Sand Coulee drainage in Fall, 1980. The three locations (Appendix D) are Sand Coulee Creek at Centerville, below the confluence with Cottonwood Creek (CF-03); Sand Coulee Creek at Tracy, above the confluence with Straight Creek (CF-02); and Straight Creek north of the town of Sand Coulee (AF-01). The stations were installed with modified 90 degree V-notch weir plates, having a 30 degree cutout at the base to a gage height of 1.12 feet. The 30 degree modification was designed to increase the resolution of low-flow determinations, up to a discharge of about 1 cfs.

Stevens Type A recorders were employed in the stilling wells. The Centerville weir accommodated flows up to 50 ft^3/s (gage height 4.24 ft), while the Tracy and Straight Creek weirs could measure up to 13.4 ft^3/s (gage height 2.83 ft). Design plans and rating equations used for the weirs are included in Appendix D (D-1).

Daily discharge data and stream hydrographs for the gaging stations are displayed in Appendix D (D-7). The short term data allow only tentative generalizations to be drawn, including:

1) Sand Coulee Creek shows high annual variability in discharge. During late winter and spring, its flow is dominated by runoff from snowmelt and spring rainstorms in the Sand Coulee area and in the upper reaches of the watershed in the Belt Mountains. In 1981, intense spring rainstorms in May caused flash flooding along Sand Coulee Creek in the Tracy-Centerville area, washing away the two original stilling well installations at CF-02 and CF-03. Peak flows fell gradually, and by October the main watercourse was essentially dry. It would not be unusual for Sand Coulee Creek to be dry by August in a year of "normal" precipitation and earlier in dry years. Bank and bed materials around these two stations were washed out a second time in May, 1982, again following a spell of very wet weather. The instability of the channel materials and limitations on station construction forced the abandonment of the sites. They could be reinstalled as open channel stations. Peak flows topped the weirs by over one foot (gage heights >5.0 feet).

   Low flow periods exhibited both streamflow losses and gains between the Centerville and Tracy weirs. Concurrent streamflow records in November, 1981 indicated a possible loss of 5-15 gpm in that reach. An eleven day period in latter August, 1981 indicated very little change in flows at about 300 gpm.

2) Straight Creek, despite having a watershed area of only about 4 percent the size of Sand Coulee Creek, has baseflows similar in magnitude and sometimes of longer duration. Sand Coulee Creek was dry from November through March in water year 1981, while Straight Creek had base flows of 0-10 gpm. The AMD from the many abandoned mines tributary to Straight Creek is primarily responsible. During low flows most of the water in Straight Creek infiltrates to the alluvium before the confluence with Sand Coulee Creek.

   Peak flow in 1981 occurred on May 16 and reached 21.6 ft^3/s. Summer flows generally ranged from 5.0 to 0.2 ft^3/s.

2.3.2 Seepage Profiles

A seepage profile can be viewed as an instantaneous detailed summary of variations in stream discharge throughout a watershed, although in practice the collection of this data takes as long as several days. In a stream like Sand Coulee Creek dominated by acid mine drainage, changes in water quality (pH, specific conductance, metal concentrations) also reflect variations in stream discharge and can point out stream gains or losses.

Acid mine drainage discharges into surface water systems and undergoes changes in both quality and quantity early in its downstream flow. Changes in surface-water quantity include losses, primarily streambed infiltration, and gains, primarly inflow from tributary drainages and seepage from shallow ground-water discharge. Changes in quality are primarily due to mixing with tributary streams and to precipitation reactions caused by oxidation of the acid water. Seepage profile data were collected to investigate these downstream changes in discharge and water quality and to relate them to the interaction of the ground water and surface water. All stream seepage profile sites are shown in Appendix D (D-2).

2.3.2.1 Number Five Coulee

The seepage profile on Number Five Coulee, conducted March 14, 1981 was terminated prematurely when a temporary restraining dam was breached. However, eleven measurements were made beforehand between the Giffen mine and the confluence with Cottonwood Creek. Streamflow measurements were made with a hand-held pressure-diaphragm current meter, readable to 0.1 ft/sec.

There were both gains and losses, but there appeared to be a tendency for decreasing streamflow possibly indicating losses to alluvium and bedrock. The net loss between successive measurements along the approximately four stream miles ranged from 24 to 104 gpm, and is depicted in Appendix D (D-3). The pH and specific conductance at the 11 sites remained relatively constant, with pH values from 6.05 to 6.68 and specific conductance values from 1159 to 1228 us/cm (see Appendix D (D-4 and D-5).

2.3.2.2 Sand Coulee-Cottonwood Creek

Seepage characteristics of Sand Coulee and Cottonwood Creeks were determined with 21 seepage run stations established from 8-26-81, 1500 hrs., to 8-29-81, 1000 hrs. (see Appendix D). These included tributary flows entering at DF01 (Sand Coulee Creek), BF01 (Number Five Creek), and AF01 (Straight Creek), as well as 18 temporary stations installed along the main drainage of the area formed by Cottonwood and Sand Coulee Creeks (CF01-CF18). The three permanent gaging stations were included in the seepage profile. Discharge was measured at each station except these three using a portable reinforced plywood 90-degree V-notch weir, graduated in hundredths of a foot. At each station the weir was installed and leveled across the channel using clay and mud. The water level was allowed to rise to equilibrium behind the weir, at which time the gage height was noted. At stations where the stream gradient was high, equilibrium was achieved within a few minutes; under gentler gradients, slow rise in water level persisted for up to four hours. At all stations except one (CF01), an equilibrium gage height was attained. The relative error of the technique is estimated at ± 5

percent. The field pH and S.C. were measured at each station. In addition, seven water quality samples were collected and analyzed for major element chemistry and for both total recoverable and dissolved metals (Appendix D, D-6). The discharge at AF01 had been sampled and analyzed six weeks earlier, on 7-17-81, and in light of the low variability of discharge, conductance and pH between these two dates, the data from this earlier analysis were considered representative of AF01 during the seepage profile.

The results indicate that about 1078 gpm of surface water was input and about 1065 gpm was lost from Sand Coulee Creek as channel seepage and evapotranspiration between the uppermost point 5 miles south of Stockett and the mouth of the creek at the Missouri River.

Evapotranspirational losses in warm months complicate the interpretation of seepage profile data. Diurnal fluctuations of hydrographs from gaging stations on Sand Coulee Creek and Straight Creek indicate peak evapotranspirational withdrawals of 20 to 30 gpm and average daily withdrawals of 9 to 14 gpm. An estimate of the total direct evapotranspirational withdrawal over the entire stream length under study was made by using an average stream width of 4.7 feet, a length of 24 miles (DNRC, 1979) and the August, 1981 average daily corrected evaporation rate of 0.0168 ft/day, a mean of the U.S. Weather Bureau's Canyon Ferry and Moccasin experiment station pan data (U.S. Dept. of Commerce, 1982). The average evapotranspirational loss rate from the stream was thus estimated to be 52 gpm, or about 2.17 gpm per stream mile.

The total net streamflow losses to ground water, by difference, equalled 1013 gpm. Using more conservative criteria, stream losses to

infiltration and ground water would be occurring, when between two consecutive measurements, a loss remains after obtaining the minimum difference of each pair of measurements ± 5%, to allow for possible measurement error, minus 2.17 gpm/mi due to evapotranspirational effects.

Based on these criteria, seven of the eleven measured stream segments exhibited streamflow losses to infiltration ranging from rates of 7 to 108 gpm per stream mile. Losses to infiltration using the above criteria for all seven stream segments totaled 958 gpm. If all the gains in streamflow and evapotranspiration losses for the other four segments are subtracted, a net minimum overall streamflow loss to infiltration of 815 gpm remains.

A set of current meter measurements were made in August, 1982 to re-check stream seepage losses from several segments of Sand Coulee and Cottonwood Creeks. The results again confirmed a loss of about 100 gpm between Stockett and No. 5 Coulee on Cottonwood Creek. A very small gain was measured between No. 5 Coulee and CF03 and a gain of 168 gpm measured between CF03 and CF02.

A flow measurement was made on upper Sand Coulee Creek (T. 17 N., R. 5 E., 7, BA) about 17.5 stream miles above Centerville. At that point the flow was 2.9 ft^3/s, pH was near 7.0 and S.C. equaled 672 us/cm. Sand Coulee Creek at Centerville just above Cottonwood Creek discharged only 1-2 gpm, indicating that the mainstem of Sand Coulee Creek also loses substantial amounts of water to subsurface seepage.

Water quality data collected during seepage profiles (Appendix D (D-7)) indicate the major impact which AMD had on streamflow. Cottonwood Creek above AMD influence had a pH of 7.33 to 8.26 and a

specific conductance of 418 to 476 us/cm. Downstream at Stockett, pH was 3.16 and S.C. equaled 1,641 us/cm. Just above Centerville, Cottonwood Creek had a pH of 3.34 and an S.C. of 1,233 us/cm.

Sand Coulee Creek below Centerville had pH values ranging from 3.42 to 2.60, and S.C. values of 1,267 to 3,151 us/cm. The pH decreased below the confluence with Straight Creek, and S.C. showed a tendency to increase in the downstream direction, with the highest value just above the confluence with the Missouri River.

Effects of both evapotranspiration and acid neutralization reactions will increase the total dissolved solids concentration of the stream. Stream pH is affected markedly by both the influx of more acid or alkaline tributary water and by oxidation of dissolved ferrous iron to the rust-red ferric hydroxide precipitate which coats the channel of Sand Coulee Creek and produces additional acid.

2.4 Hydrologic Summary

The Sand Coulee Creek watershed has a dynamic hydrologic system in which the effects of acid mine drainage from abandoned underground coal mines plays a significant role in terms of volume and water quality impacts. Peak stream flows are of short duration and influenced primarily by spring and early summer rainstorms over the entire basin which extends to the Little Belt Mountains. Baseflow in streams originates primarily as ground-water discharge from the surficial Kootenai Formation, which is extensively fractured, and transmits meteoric recharge as ground-water flow to the contact with the underlying less permeable Morrison Formation, where springs and seeps contribute to streamflow. Where the Morrison coal seam has been mined, ground water leaks into the old workings where pyrite is oxidized, creating acid water which discharges to streams from old mine portals. From Stockett and Sand Coulee to the Missouri River, the baseflow of Sand Coulee Creek is primarily composed of acid mine drainage water. Very little of the acid baseflow leaves the watershed as streamflow, most of the water leaving either as evapotranspiration or being lost to subsurface seepage to alluvial and bedrock aquifers.

3. Chemical Modeling of Ground-Water Quality

3.1 Introduction

One of the significant discoveries of this project was the unanticipated poor chemical quality of ground-water sampled from some domestic wells in the study area. The dissolved solids, sulfate, and occasionally trace metal content of some Madison aquifer wells were much higher than the Madison ground water typically possessed even

farther down the flow system, namely, in the Great Falls vicinity.

The predominately downward vertical gradients, regional fracturing and solution permeability associated with the area create conditions favorable for leakage of acid mine drainage from contaminated streams and alluvium into lower aquifers, principally the Swift and Madison.

Chemical modeling calculations were conducted in an attempt to explain the mechanisms and dynamics of potential AMD contamination of the alluvial, Swift and Madison aquifers.

The primary objective of the modeling calculations was to provide some ideas on the constraints that equilibrium or near equilibrium mineral-aqueous phase relationships place upon the chemical composition of ground water. These results are then used to evaluate the mixing of various "type" waters. The result is a minimum and maximum value for the amount of acid mine drainage responsible for the impacted water quality of wells in the (deeper) Madison aquifer. The methodology employed is similar to that described by Plummer et al. (1983), using the program PHREEQE (Parkhurst et al., 1980). Acid-mine drainage from adit AS-03 was used as an end member type water. Two water samples, from the Kunesh and Net wells, were used as end member "uncontaminated" Madison type waters. The following sections describe the results of a pure mixing model and two different reaction models. We will compare the predicted product phases with cuttings from the planned 1983 drilling program to evaluate which of these models most closely resembles the natural system for further predictive input.

3.2 Mixing Model

The product of a mixing model is simply a synthetic water analysis

in which X percent of water A is mixed with Y percent of water B (X + Y = 100) to yield a hypothetical water C, which is the best possible approximation of an observed water quality (water D). In order to accomplish this calculation, at least one constituent must be treated as "conservative," i.e., no additions or subtractions of this parameter occur. AS-03 drainage and the Kunish well water were used as waters A and B; sulfate, which constitutes the major anion species, was treated conservatively. The calculated mixing ratio is 19 percent AS-03 water and 81 percent Kunesh well water. Results of these calculations may be found in Table 3.

3.3 Reaction-Mixing Model 1

Because the mixing-model results provide a very poor correlation in terms of Fe, Ca, Mg, pH, and HCO_3, a reaction model was used to evaluate the dissolution of limestone and dolomite by the acid mine drainage. Reaction steps for this model are: (1) precipitation of gibbsite and amorphous ferric hydroxide; (2) dissolution of calcite and dolomite plus precipitation of $Al(OH)_3$ and $Fe(OH)_3$; (3) degassing to atmospheric partial pressure of carbon dioxide (P_{CO2}); and (4) mixing 19 percent modified AS-03 water with 81 percent Knox water and increasing the P_{CO2} to atmospheric. Results of this approach, shown as analysis E in Table 3, provide a reasonably good match with the water in the Knox well.

3.4 Reaction-Mixing Model 2

The major drawback to the first reaction-mixing model is that it ignored the supersaturation of the water with respect to gypsum.

Gypsum precipitation would remove sulfate from the water, thereby requiring a greater percentage of acid mine drainage to result in hypothetical mix water similar to that from an impacted well.

For this model, a low total dissolved solids well water (Net well), was used, and a less severely impacted Madison aquifer well (Senior Citizens well, Centerville) was the control well. Mass balance calculations were not used to control the mixing ratio. Instead, the modeling steps were: (1) react AS-03 water with limestone precipitating $Fe(OH)_3$, $Al(OH)_3$, and fluorite at saturation levels, precipitating gypsum at slightly supersaturated levels, releasing CO_2 once $P_{CO2} = 10^{-0.75}$ atmosphere, and dissolving calcite until slightly undersaturated; (2) mixing water from the previous step with Net well water, dissolving a small amount of dolomite and precipiating small amounts of chalcedony and calcite. This procedure required 45 percent modified AS-03 water and 55 percent Net well water to approximately match the water quality in the Senior Citizens well.

3.5 Discussion

The models provide insight as to the probable range of mixing within the Madison aquifer of acid mine drainage waters with "pristine" ground water. The authors hypothesize that plumes of significantly degraded water within the Madison aquifer are probably restricted to the areas immediately down gradient from discharging mines, in the vicinity of leaky Madison well bores and near acid contaminated streams traversing Madison outcrops or alluvial subcrops.

4. Evaluation of Proposed Mitigation Alternatives

Previous analyses of acid mine drainage treatments for the Sand Coulee area (McArthur, 1970; Hydrometrics, 1982) focused on centralized neutralization or mine manipulation methods. Knowledge of the hydrodynamics and hydrogeology of the AMD problem gained in this investigation allows new evaluations of old techniques and the suggestion of some new mitigation alternatives.

Five AMD control techniques were proposed for field testing in the Stockett-Sand Coulee area based on this and previous work by the Montana Bureau of Mines (MBMG) and others. In addition to being summarized below, the five methods were presented on a proposal to the Montana Department of State Lands (DSL) (Appendix E). They subsequently agreed to provide funding for field testing of two methods: infiltration control through increased evapotranspiration and drainage wells.

An investigation of the extent of acid mine drainage contamination in the alluvium of the lower Sand Coulee Creek watershed was proposed and also funded by DSL for 1983-84.

4.1 Infiltration Control

A minimum of two test sites are proposed to monitor the effectiveness of perennial deep-rooted crops (eg. alfalfa and sanfoin) and flexible-cropping techniques in reducing ground-water recharge to the Kootenai aquifer overlying the old coal mine workings. Research in dryland saline-seep control has shown intensive cropping techniques to be an effective tool in the control of shallow ground-water flow systems, when applied with a sound farm management plan. An organization such as the Triangle Conservation District, Conrad, Montana, would supply the required farm plan expertise to the farmers involved. Moni-

toring of ground-water level trends and of key AMD discharges would quantify the effectiveness of this approach.

4.2 Drainage Wells

Dewatering of the Kootenai aquifer with vertical wells may be possible, but is undesirable due to long-term pumpage requirements. We propose that horizontal test wells be drilled into the basal Kootenai sandstone aquifer upgradient from old mine workings at two sites. Gravity drainage of Kootenai ground water will eliminate pumpage, may substantially reduce AMD discharge of the test sites and will make more fresh water available for dilution of remaining AMD in receiving streams. Horizontal dewatering wells have been used successfully in Montana for highway construction and mining purposes in the past. Vertical connector wells which would allow gravity drainage of Kootenai ground water to the Madison aquifer, are another alternative which may be tested once detailed information on the aquifers and old mine workings is developed. Vertical test hole drilling and geophysical techniques would be used to map the location of old mine workings.

4.3 Subsurface Injection of AMD

Madison limestone rocks underlie the entire Sand Coulee watershed and could be an effective decentralized, disposal and neutralization medium for AMD. However, the Madison is also an important aquifer that must not be adversely impacted. Logging, sampling and analyses of Madison rocks from several test wells will indicate its physical characteristics. Aquifer testing and water quality sampling will be done to determine initial permeability characteristics estimate end products of

mixing AMD and Madison water. An initial 10-day injection test, and a second 100-day test would be conducted during which time extensive water quality and ground water level monitoring would be done. Following the tests, geophysical logs would be re-run on the test holes, aquifer test re-run to determine permeability changes and at least two new bore holes drilled and cored to sample precipitates. Hydrochemical modeling would be done to predict the long-term feasibility and impacts of an injection program.

4.4 Flyash Neutralization

MBMG studies have documented the effectiveness of flyash in neutralizing pyrite induced acidity and reducing iron mobility of mine tailing waters (Sonderegger and Donovan, 1982). A field test of the effectiveness and maintenance requirements of a small flyash pit in neutralizing small acid discharges in the Sand Coulee area would be conducted. Pits of about 200 ft^3 in size would be filled with flyash and acid inflows of 1 gpm or less allowed to seep upward through the pits, being neutralized prior to discharge from the lower end. Water quality sampling and pit excavations would establish the effectiveness of the technique.

4.5 Kootenai Neutralization

A simple and possibly effective AMD neutralization technique would be to mix naturally alkaline Kootenai ground water with small volumes of acid mine water. Mixing would occur in a pit where metals would be allowed to precipitate prior to discharge of the effluent. Typical AMD acidity and Kootenai ground-water alkalinity requires a 1 to 10

volumetric mix for theoretical neturalization. The technique will be evaluated by taking water quality samples and field measurements of the inflow and outflow.

4.6 Alluvial Ground-Water Contamination Mapping

The alluvial valley of Sand Coulee Creek joins an abandoned pre-glacial channel of the Missouri River. Residents all along lower Sand Coulee Creek abandoned alluvial wells years ago due to AMD contamination and even the Madison aquifer is contaminated in places. The many years of AMD seepage losses along the seven miles of old Missouri River alluvium have had a so-far undocumented impact on shallow ground-water supplies in the Great Falls area. It is proposed to conduct a reconnaissance shallow well drilling and sampling program in the old channel to document the extent of AMD contamination. Ground water flow gradients and the extent and severity of water quality conditions would be mapped.

5. Summary

The numerous abandoned underground coal mines in the Stockett-Sand Coulee area discharge a combined rate of 1-4 ft^3/s of acid water (pH = 2-5) with a high dissolved and suspended metal load. The sources of the water is primarily downward leakage from the surficial Kootenai formation. The acid water comprises 60-90 percent of the total flow of Sand Coulee Creek in baseflow periods. Most of this flow is lost to evapotranspiration and leakage to alluvial and deeper bedrock aquifers, namely, the Swift sandstone (Jurassic) and Mission Canyon limestone (Mississippian) of the Madison group rocks.

Ground-water quality in the Kootenai aquifer is good, with TDS in the 300 to 450 mg/l range and alkalinity averaging about 340 mg/l as $CaCO_3$. Water in the alluvium, downgradient from discharging acid sources is mostly contaminated such that very few domestic wells utilize this source. Water quality in the Swift and Madison aquifers is variable with unexpectedly high TDS and sulfate concentrations (maximum TDS = 2,413 mg/l, maximum sulfate = 1,580 mg/l) sampled in some domestic wells. This is believed to be caused by mixing with downward leaking AMD water from alluvium, well bores and places where contaminated streams traverse outcrops of Madison rocks.

A combination of AMD treatment techniques may prove to be the best long range mitigation approach. Five control measures were recommended for field testing: 1) infiltration control using intensive cropping methods in recharge areas; 2) connector and horizontal wells to dewater the Kootenai aquifer overlying the old mines; 3) injection and neutralization of acid water in the Madison limestone; 4) neutralization of small AMD sources in flyash pits; 5) neutralization of small AMD sources in pits with naturally alkaline Kootenai ground water.

TABLE 1

Correlations of Mine Designations Used in the Sand Coulee drainage.

MBMG No.	Location	Name	McArthur No.[5]	Hydrometrics No
[1]AS-01	19N04E23ADCB	Upper Carbon Mine	23-6	SCM-2
AS-02A	19N04E23ADAB	Lower Carbon Mine	23-5	SCM-3
AS-02B	19N04E23ADAB	Lower Carbon Mine	23-5	
AS-04	19N04E14DDED	Brown Mine	14-1	SCM-5
AS-06	19N04E13CBA			
[2]AS-07	19N04E13CBD	Nelson Mine	13-3	SCM-6
[3]BS-01	18N04E14ACD	Giffen Mine	14-16	SCM-4
[4]CS-01A	19N05E07CACD	Tracy Mine	7-2	SCM-8
CS-01B	19N05E07CACD	Tracy Mine	7-2	SCM-8
CS-02	19N05E07DBC			
CS-03	19N05E18A			
CS-04	19N05E18DDC			
CS-05	19N05E19ACD			
CS-06	19N05E18DCC		13-6	SCM-11
CS-07	19N05E19BAA			
CS-08	19N05E19ABB			
CS-09A	18N05E06CDB	Number 6 Mine	6-1	SCM-9
CS-09B	18N05E06CDB	Number 6 Mine	6-1	
DS-01	19N05E20BBB			
SCM-7	19N05E07ABD	Badwater Johnson Mine	7-9	SCM-7
SCM-15	19N05E07AAAA	Goodwater Johnson Mine	7-8	SCM-15

[1] A: Straight Creek
[2] B: Number Five Coulee
[3] C: Sand Coulee Creek below Centerville
[4] D: Sand Coulee Creek above Centerville

[5] McArthur, 1970
[6] Hydrometrics, 1982

TABLE 2

Acid Discharge Characteristics, 1980-83

Site	Observed Range Flow (gpm)	pH	S.C. us/cm
AS-01	43-500	2.21-3.01	4679-5349
AS-02a	7-26	1.99-2.82	2316-8047
AS-03	0-5	2.48-2.79	5363-6974
AS-04	45-67	3.84-4.20	3083-3487
AS-05	0-50	2.90-3.42	3352-3406
AS-06	0-38	2.80-3.10	1701-3469
AS-07	12.5-250	2.21-3.67	5023-10,306
BS-01	150-351	3.44-5.41	1038-8652
CS-01	14.3-39.7	2.28-2.88	1487-2103
CS-02	0-4.8	2.85	1387-1817
CS-06	0-0.61	3.45	8892
CS-07	1.1	2.27	15,732
CS-09	10.0-38.1	2.25-2.60	4865-7365
CS-10	0-80	1.50-2.55	10,114-10,591
DS-01	0-6	2.80	2283
SCM-7	5-15	2.3-2.35	2820-4243
SCM-15	3.8-7	3.02-6.3	1004-1100

Table 3. Major Element Water Chemistry for Modeling AMD Contribution to Impacted Wells.

	A AS-03	B Kunesh Well	C Synthetic Mix	D Knox Well	E Reaction Path 1	F Net Well	G Senior Citizens Well	H Reaction Path 2
Lab No.	81Q0057	79M3253		81Q1088		82Q0499	83Q0001	
Ca	292.	79.9	120.2	487.	456.	65.5	241.	204.
Mg	190.	32.	62.	146.	121.	23.6	135.	123.
Na	17.1	10.1	11.4	28.9	11.4	7.1	23.1	11.7
K	1.1	2.3	2.07	7.5	2.1	3.1	4.1	2.2
Fe	944.	0.05	179.	0.15	0.045	0.018	<.002	0.012
Mn	2.84	0.00	0.54	0.016	0.53	0.002	0.004	1.292
SiO_2	116.	10.9	30.9	19.8	30.6	15.7	16.9	12.0
HCO_3	---	235.	190.	261.	343.	271.	440.	636.
Cl	2.0	4.9	4.3	5.1	4.4	3.1	23.3	2.6
SO_4	7700.	145.	1580.	1580.	1562.	65.7	755.	747.
NO_3(as N)	1.7	0.32	0.58	9.04	---	5.69	12.4	---
F	12.8	0.57	2.89	0.66	0.46	0.50	1.1	0.85
pH	3.38	7.4	4.10*	6.33	7.60	7.12	5.7	6.82
TDS	9280.	402.	2087.	2413.	2358.	324.	1411.	1417.

*$pH = -\log_{10} (0.19 \times 10^{-pH_A}) + (0.81 \times 10^{-p_{HB}})$

TABLE 4

Selected Well Inventory Data for the Sand Coulee Area

NO.[1]	AQUIFER	LAND ELEVATION ft, msl	TOTAL DEPTH ft	STATIC WATER LEVEL ft, msl	S.C. us/cm	DATE MEASURED[2]
Q1	Alluvium	3800	35	3784.02	983	6-4-82
K1	Kootenai	4303	90	4228.12		8-19-82
K2	Kootenai	4075	131	4057.32	677	6-21-82
K3	Kootenai		75	4356.18	506	8-19-82
J1	Jurrassic	3695	58	3665.52		6-2-82
J2	Jurrassic	3390	100	3365.27	1336	5-27-82
M1	Madison Limestone	3440	158	3338.64	612	6-9-82
M2	Madison Limestone	3430	168	3320.22	700	6-18-82
M3	Madison Limestone	3457	175	3374.44	595	6-5-82
M4	Madison Limestone	3455	220	3448.67	1667	6-4-82
M5	Madison Limestone	3460	185	3311.32	617	6-10-82
M6	Madison Limestone	3455	175	3375.24	597	6-19-82
M7	Madison Limestone	3475	200	3352.08	2292	6-9-82
M8	Madison Limestone	3510	290	3313.1	826	6-20-82
M9	Madison Limestone	3490	258	3408.3	2911	6-2-82
M10	Madison Limestone	3400	125	3334.19	1698	5-28-82
M11	Madison Limestone	3418	200	3345.85		5-28-82

[1] Refers to Figure 6.
[2] All measurements by MBMG.

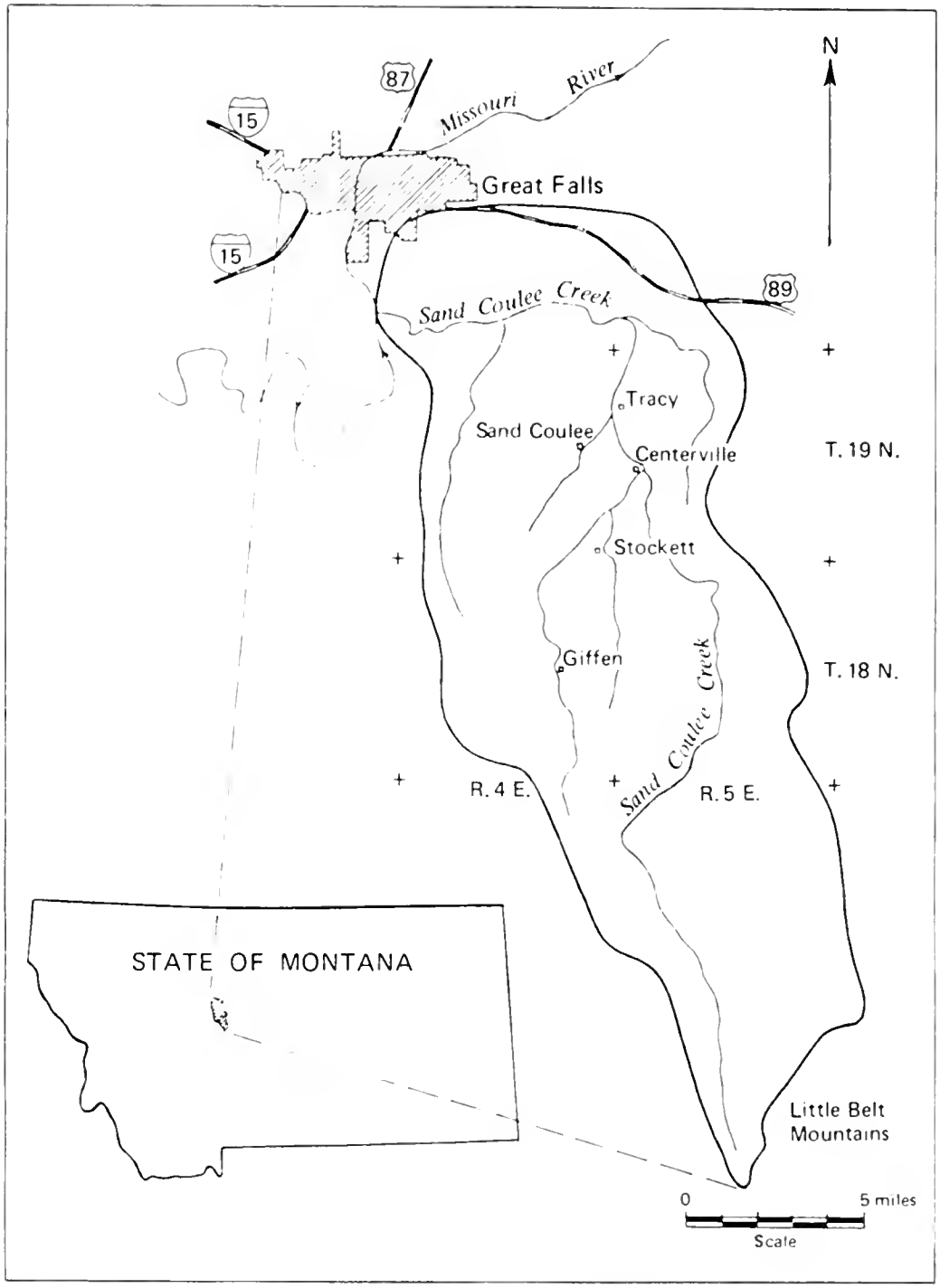


Figure 1. Location of study area.

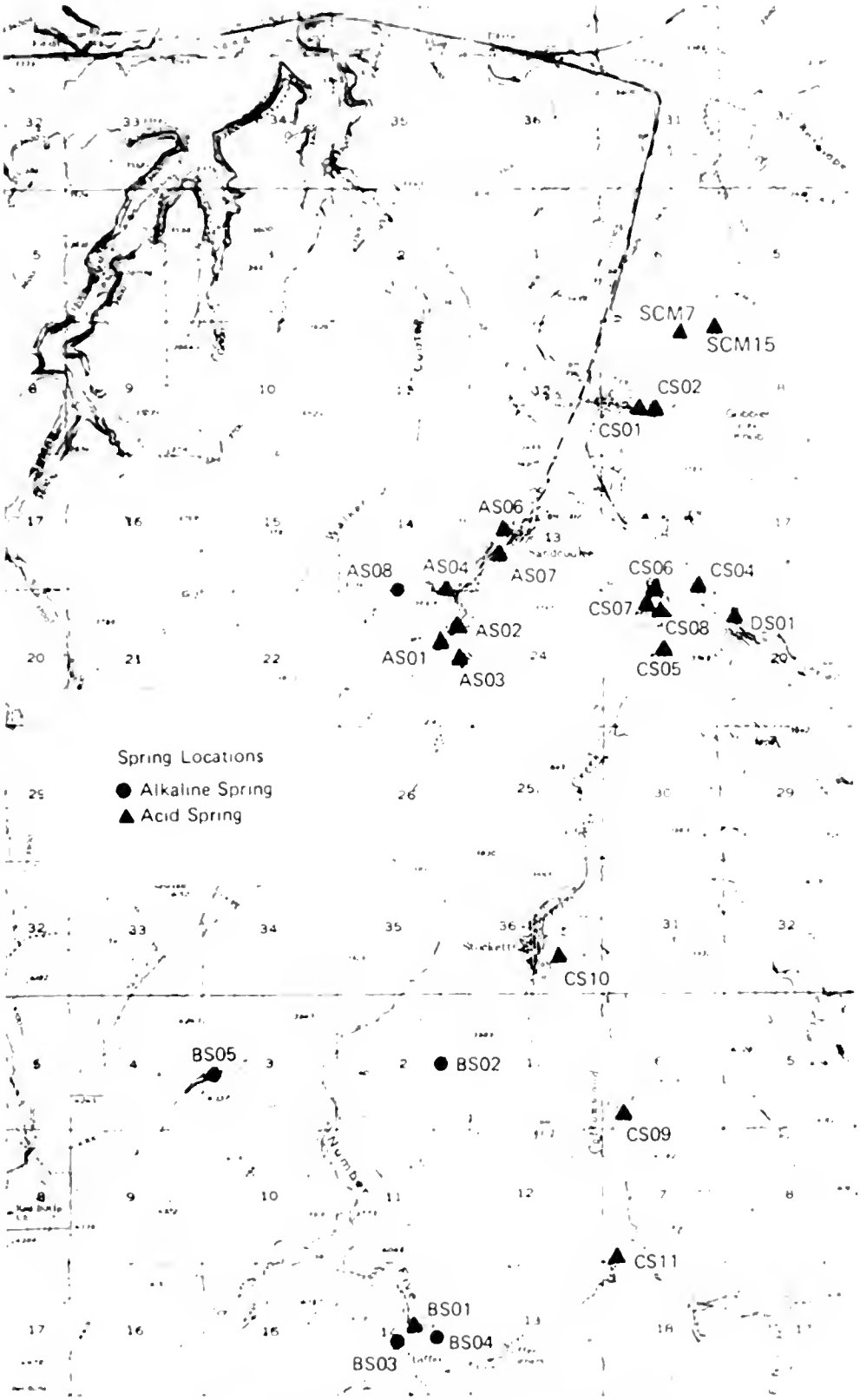


Figure 2. Location of springs and acid discharges.

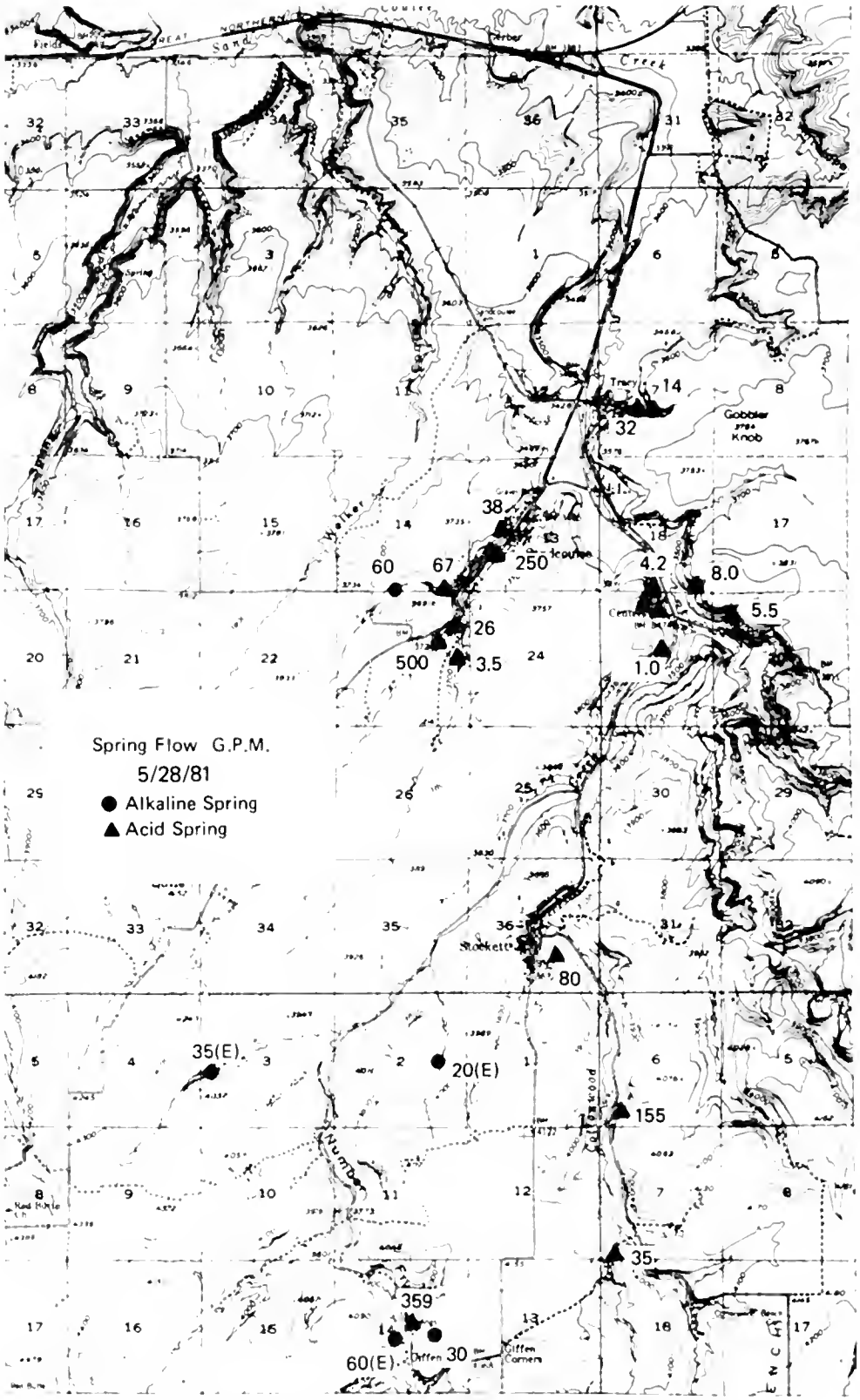


Figure 3. Discharge, in gallons per minute, of springs on May 28, 1981.

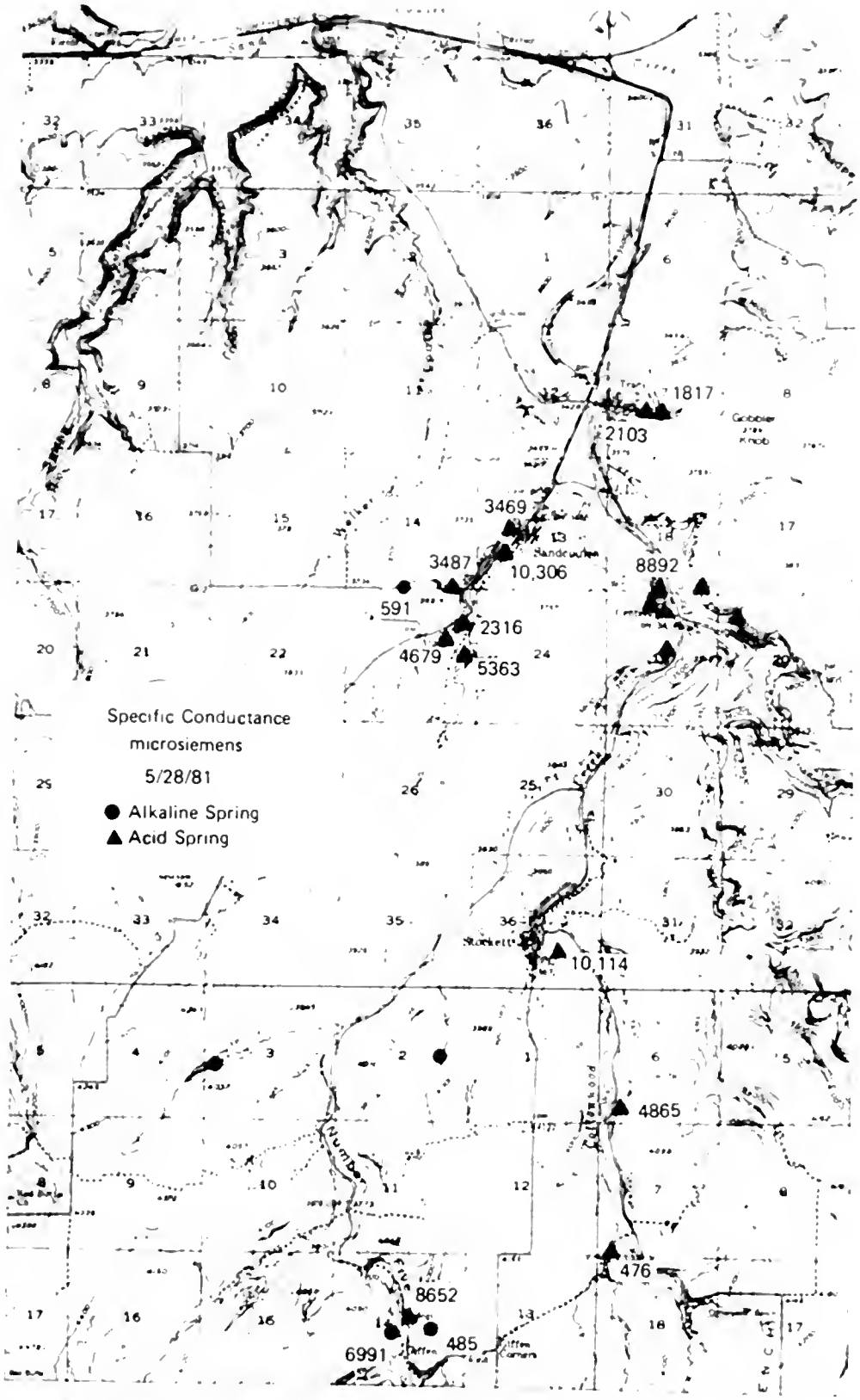


Figure 4. Specific conductance of springs in microsiemans/cm (μS/cm) on May 28, 1981.

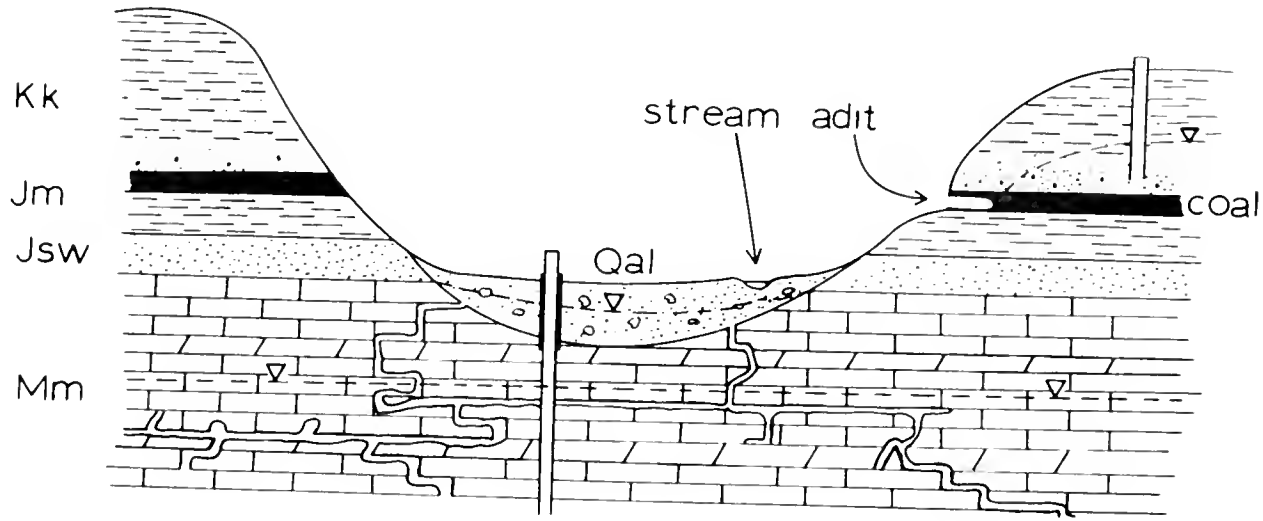


Figure 5. Schematic cross section through a coulee. Not to scale. Kk=Kootenai Formation; Jm=Morrison Formation; Jsw=Swift Formation; Mm=Madison Group. Thickness of the coal and the Swift Formation are exaggerated. The symbol ▽ represents the water table.

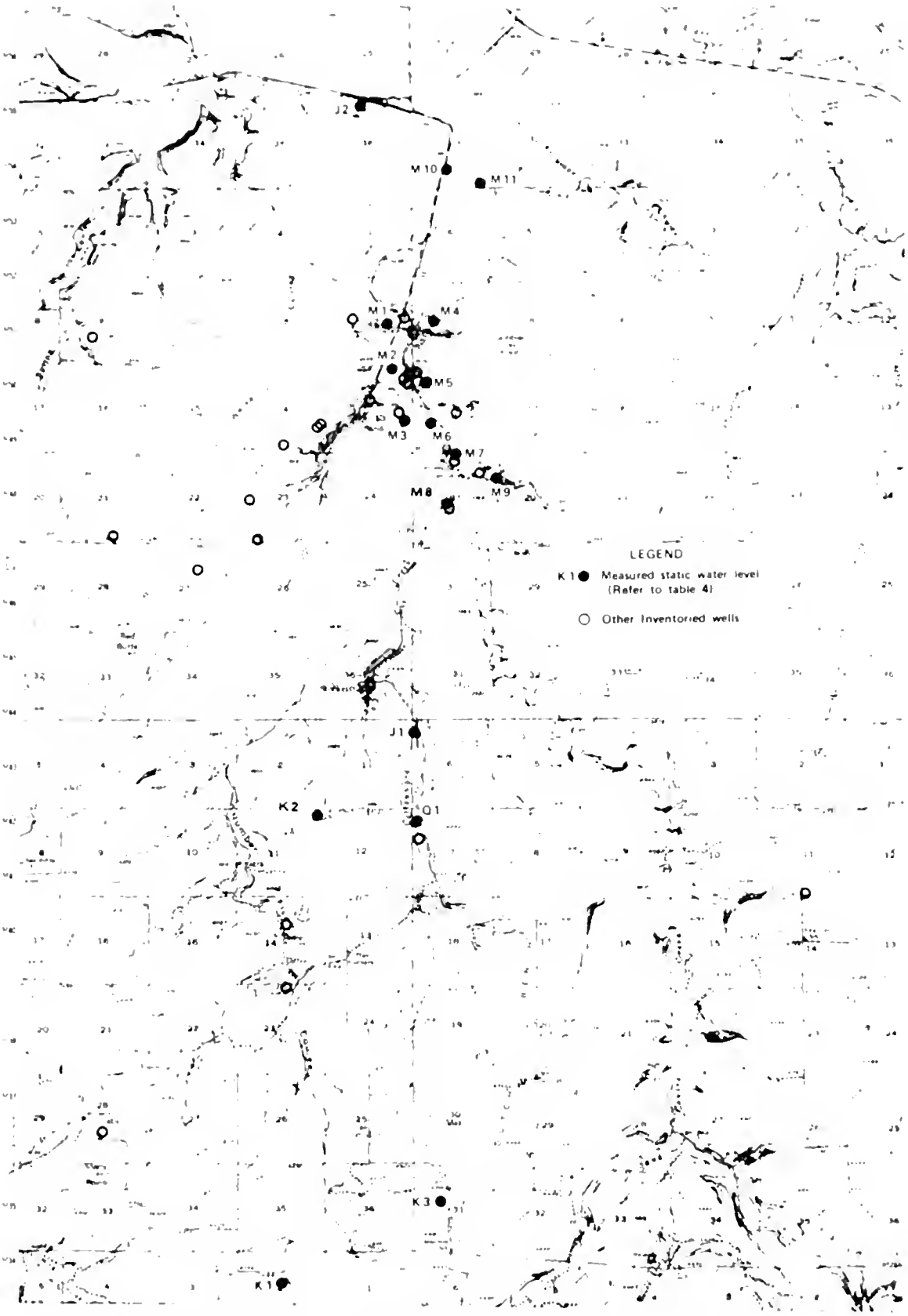


Figure 6. Location of domestic wells inventoried by MBMG, 1982.

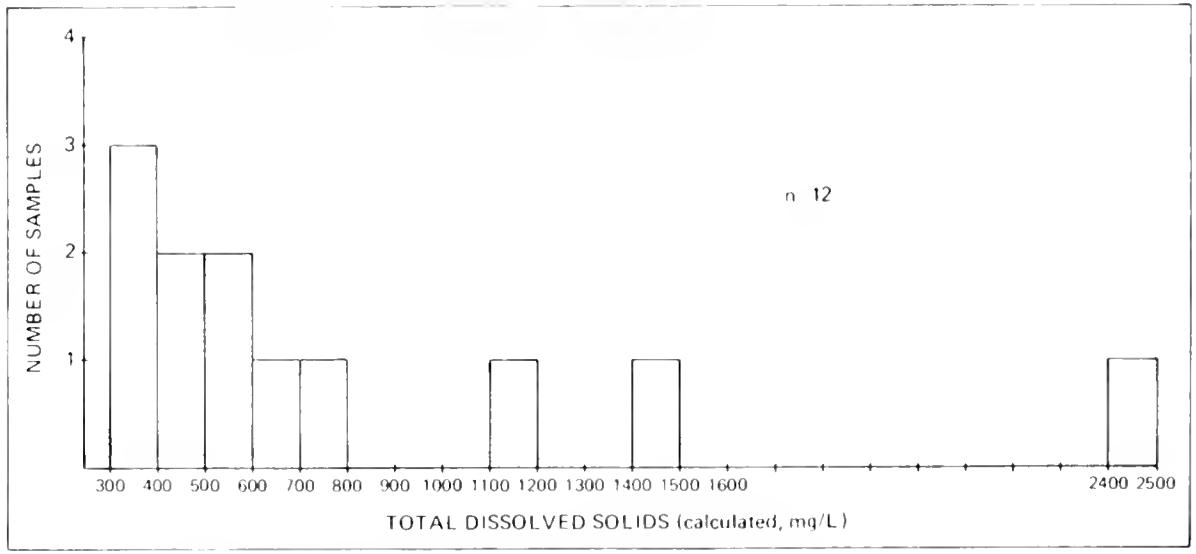


Figure 7. Frequency distribution of total dissolved solids (calculated, mg/L) for water samples from the Madison aquifer, Sand Coulee area, Montana.

I.D.	Lab number	T.D.S. (mg/L)
A	82Q0490	611
B	82Q0496	500
C	81Q1088	2410
D	83Q0001	1410
E	82Q0499	324
F	82Q0497	573
G	82Q0493	393
H	83Q0003	569
I	82Q0504	435
J	83Q0002	785
K	82Q0500	387
L	82Q0501	1150

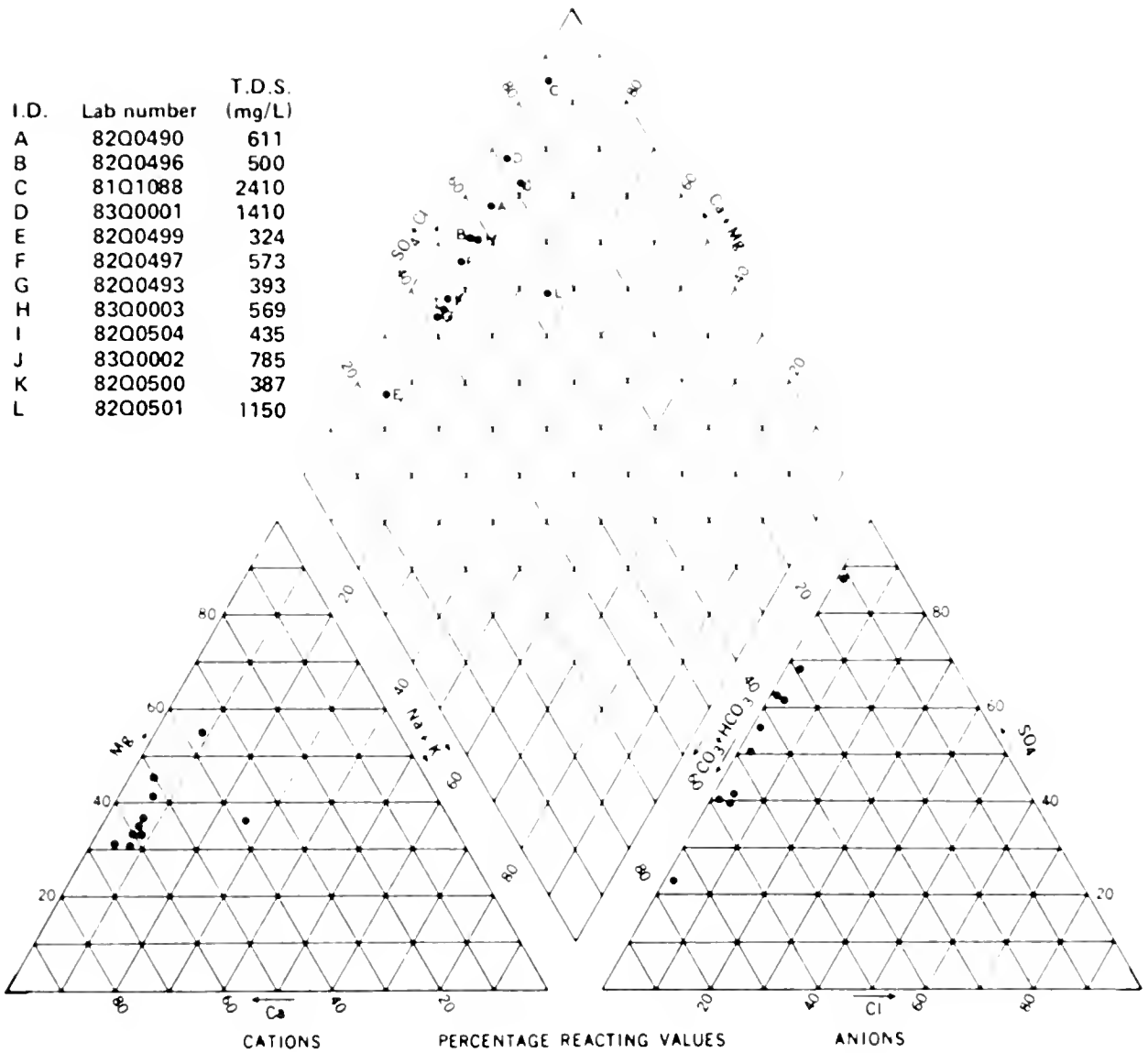


Figure 8. Piper plot of water analyses from Madison Group wells, Stockett - Sand Coulee area, Montana.

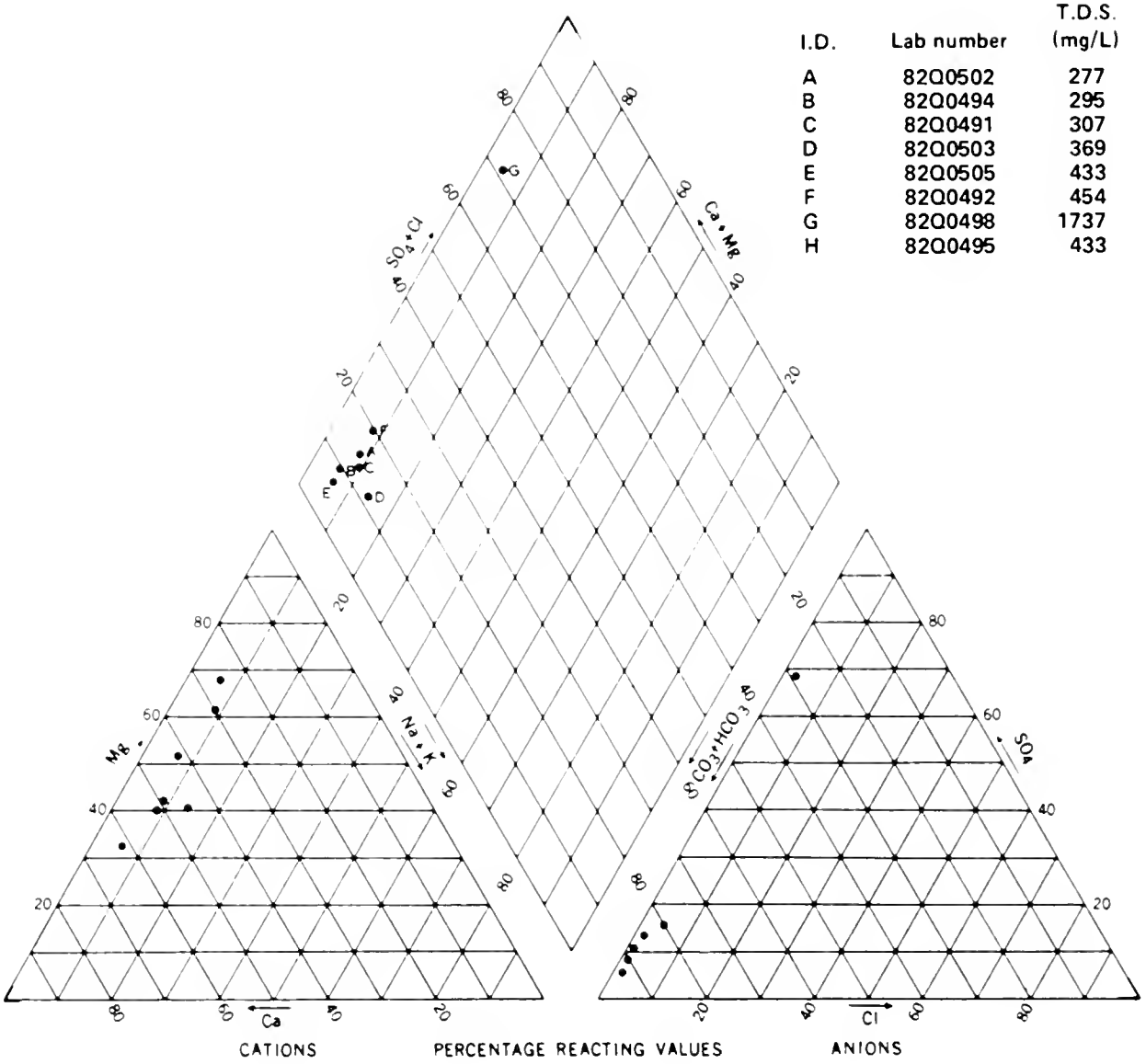


Figure 9. Piper plot of water analyses from Jurassic and Kootenai wells, Stockett - Sand Coulee area, Montana.

REFERENCES

Alden, W. C., 1932, Physiography and glacial geology of eastern Montana and adjacent areas: U.S. Geological Survey Prof. Paper 174, 133 p.

Bituminous Coal Research, Inc., 1971, Studies of Limestone Treatment of Acid/Mine Drainage, Part II, EPA Grant No. 14010 EIZ.

Brown, P. L. and Miller, M. R., 1978, Soils and crop management practices to control saline seeps in the U.S. northern plains. In: Dryland-saline-seep control, Proceedings Meeting of Sub commission on Salt-Affected Soils at 11th. Int. Soil Sci. Soc. Congr., Edmonton, Alberta, Canada, pp. 7-9 to 7-15.

Bush, P. W., 1983, Connector Well Experiment to Recharge the Floridan: Aquifer, East Orange County, Florida: U.S. Geological Survey Water-Supply Paper-2210, 25 p.

Coulton, R. B., Lemke, R. W., and Lindvall, R. M., 1961, Glacial Map of Montana East of the Rocky Mountains, U.S. Geological Survey MISC. Geologic Inves. Map I-327.

Diebold, F. E., 1975, Treatment of Acid Mine Drainage from the Block P Mine and Dump at Hugesville, Montana, Dept. of Chemistry, Montana College of Mineral Science and Technology, Butte, Montana.

Dodge, T., Holzer, J., Adams, W., Farkell, J., (Triangle Conservation District, Conrad, Montana) and M. R. Miller (Montana Bureau of Mines and Geology, Montana Tech, Butte, Montana), in press, Triangle Conservation District: A case study in dryland saline seep control. Proceedings of International symposium on state-of-the-art control of salinity, July 13, 1983, Salt Lake City, UT.

Feltis, R. D., 1980, Dissolved-solids and ratio maps of Water in the Madison Group, Montana: Montana Bureau of Mines and Geology-Hydrologic Map 3.

Feltis, R. D., 1980, (2), Potentiometric surface map of water in the Madison Group, Montana: Montana Bureau of Mines and Geology Hydrogeologic Map 2.

Feltis, R. D., 1980 (3), Structure Contour Map of the top of the Madison Group Great Falls 1^{o} x 2^{o} Quadrangle, North-Central Montana, Montana Bureau of Mines and Geology, Geologic Map 10.

Fisher, C. A., 1909, Geology of the Great Falls Coal Field, Montana: U.S. Geological Survey Bulletin 356, 85 p.

Goers, J. W., 1964, Geology and Groundwater Resources Stockett-Smith River Area, Montana: unpub. M.S. Thesis, University of Montana, Missoula, 128 p.

Hydrometrics Inc., 1982, Abondoned Mine Lands Belt-Sand Coulee, Montana, v. IIa, 151 p., report for Montana Department of State Lands, Capitol Station, Helena, Montana 59601.

Kim, A. G., Heisey, B. S., Kleinmann, R. L. P., and Deul, M., 1982, Acid Mine Drainage: Control and Abatement Research: Bureau of Mines Information Circular-8905, 22 p.

McArthur, G. M., 1970, Final Report on Acid Mine Waste Pollution Abatement, Sand Coulee Creek, Montana: Engineering Research Laboratories, Montana State University, Bozeman.

Miller, M. R., Donovan, J. J., Bergantino, R. N., Sonderegger, J. L., and Schmidt, F. A., 1981, Montana Bureau of Mines and Geology, Brown, P. L., 1981, U.S. Department of Agricultural. Saline Seep Development and Control in the North American Great Plains-Hydrogeological Aspects: Agricultural Water Management, 4, 1981, pp. 115-141.

Montana Department of Natural Resources and Conservation, 1979, River Mile Index of the Missouri River, 141 p.

Parkhurst, D. L., Plummer, L. N., and Thorstenson, D. C., 1980, PHREEQE-A computer program for geochemical calculations: U. S. Geological Survey, Water Resources Invest. 80-96, 210 pp.

Patton, T. W., 1983, The Ground-Water Geology of Giant Springs, Great Falls, Montana, unpublished report: Montana Bureau of Mines and Geology, 17 p.

Plummer, L. N., Parkhurst, D. L., and Thorstenson, D. C., 1983, Development of Reaction Models for Ground-water Systems: Geochimica et Cosmochimica Acta: 1983, v. 47, no. 4, pp. 665-686.

Silverman, A. J., and Harris, W. L., 1967, Stratigraphy and Economic Geology of the Great Falls-Lewistown Coal Field, Central Montana: Montana Bureau of Mines and Geology Bulletin 56.

Sonderegger, J. L., and Donovan, J. J., 1982, Evaluation of fly ash as a tailings pond amendment for pyrite-rich tails: Montana Bureau of Mines and Geology Open-File Report 102, 42 p.

U.S. Department of Commerce, 1982, National Oceanic and Atmospheric Administration, CLIMATOLOGICAL DATA, Annual Summary, Montana, 1981, Vol. 84, No. 13.

Walker, T. F., 1974, Stratigraphy and Depositional Environments of the Morrison and Kootenai Formations in Great Falls Area, Central Montana: Unpub. Ph.D. Dissertation, University of Montana, Missoula, 40 p.

Wilke, K. R., 1983, Appraisal of Water in Bedrock Aquifers, Northern Cascade County, Montana: U.S. Geological Survey Open-File Report 82-1025, Helena, Montana, Montana Geological Survey, 29 p.

APPENDIX A

SPRING AND ACID DISCHARGE DATA

A-1

SPRING MONITORING DATA

Region: Sand Coulee Area: Test site: Reference point:

Casing abbreviations: • = Valve above GS; A = Hole abandoned; D = Dry hole; F = Flowing well; FI = Hole filled in; SI = Hole silted in; I = Hole plugged by ice or snow; S = Siphon in hole

Remarks: Spring Monitoring Data
E = estimated value
S.C. units in µS/CM (micro-mhos/cm @ 25 C)

Well No.	AS01			AS02			AS03			AS04			AS06			AS07			AS08		
GS—MP																					
Date	FLOW GPM	pH	SC	FLOW GPM	pH	SC	FLOW GPM	pH	SC	FLOW GPM	pH	SC	FLOW GPM	pH	SC	FLOW GPM	pH	SC	FLOW GPM	pH	SC
6/1-6/3/80	--	3.01	5231	--	2.36	8047	--	2.79	6673												
9/21/80	103	2.62	5102	7	2.46	5689	5	2.62	5414	29	3.84	3329	1.2	3.02	1701	40	2.38	6363	21	8.48	498
3/5/81	43	2.64	5349	10.2	2.47	7045	1.58	2.48	6622	35	3.84	3287	0.7	3.10	1781	12.5	2.50	7152	--	--	--
5/28/81	500	2.85	4679	26	2.82	2316	3.5	2.59	5363	67	4.12	2490	38	2.80	3469	250	3.67	1030	300	8.45	472
8/18/81	375	2.81	4989	18	2.77	6201	2.7	2.67	6974	18.6	4.20	3083	2.9	2.99	2762	69.8	3.20	5023	--	--	--
2/5/82	--	--	--	10.1	--	6498				4.5	3.70	2380	--	2.90	3406	40 E	2.35	5577	--	--	--
12/30/82	124	2.21	5172	10.2	1.99	7173										31	2.21	5622			
3/6/83	94	2.55	5055	11.6	2.37	6780				14.1	4.20	3225	2.2	2.80	2007	22.8	2.40	5667			

A-1

MONT BUREAU OF MINES AND GEOLOGY — WATER LEVEL FLUCTUATIONS — Appendix — BY GY DIVISION — Page 2

Region Sand Coulee — Area — Test site — Reference point

Casing abbreviations: + = Valve above GS; A = Hole abandoned; D = Dry hole; F = Flowing well; FI = Hole filled in; SI = Hole silted in; I = Hole plugged by ice or snow; S = Sub-m in hole

Remarks: Spring Monitoring Data

Well No.	BS01			BS03			BS02			BS04											
GS-MP																					
Date	FLOW GPM	pH	SC	FLOW GPM	pH	SC	Flow GPM	pH	SC	Flow GPM	pH	SC	SWL	S C	Temp	SWL	S C	Temp	SWL	SC	Temp
6/1-6/3/80	--	5.36	1738	--	8.48	699	20E	3.48	699	Dry											
9/21/80	150	5.41	1122				Dry			Dry											
3/5/81	225	5.39	1038				Dr y			Dry											
5/28/81	359	4.21	8652							30	8.08	485									
8/18/81	351	3.44	2039																		
2/5/82	--	4.05	1684	150 (E)	5.85	1575															
12/30/82	316	4.48	1252																		
3/6/83	224	4.65	1173																		

Region Sand Coulee Area Test site Reference point

Casing abbreviations: • = Valve above GS FH = Hole filled in
A = Hole abandoned SI = Hole silted in
D = Dry hole I = Hole plugged by ice or snow
F = Flowing well S = Siphon in hole

Remarks: Spring Monitoring Data

Well No.	CS01			CS02			CS04			CS05			CS06			CS07			CS09		
GS—MP																					
Date	FLOW GPM	pH	SC	FLOW GPM	pH	SC	FLOW GPM	pH	SC	FLOW GPM	pH	SC	FLOW GPM	pH	SC	FLOW GPM	pH	SC	FLOW GPM	pH	SC
6/1-6/3/80	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2.60	6226
9/21/80	20E	2.88	1862		DRY			DRY			DRY		2	2.71	5114		DRY		10	2.45	6747
3/5/81	14.3	2.77	1490	4.8	2.85	1817		DRY			DRY		0.6	3.45	8892		DRY		10.7	2.53	6923
5/28/81	55E	2.90	1635	2.2	2.82	1954		FLOWING			SEEPS		4.5	3.21	7246		SEEPS		155	2.49	3610
8/18/81	36.1	2.98	1752		DRY												DRY		38.1	2.39	7365
2/5/82	33.8	2.65	1746	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2.25	6784
12/30/83	39.7	2.88	1487																21.6	2.52	6283
3/6/83	38.2	2.75	1528		DRY									DRY					20.8	2.55	6257

MONTANA BUREAU OF MINES AND GEOLOGY

WATER LEVEL FLUCTUATIONS

HYDROLOGY DIVISION

Appendix

Region Sand Coulee Area Test site Reference point

Coding abbreviations: V = Valve above GS; A = Hole abandoned; D = Dry hole; F = Flowing well; FI = Hole filled in; SI = Hole silted in; I = Hole plugged by ice or snow; S = Siphon in hole

Remarks: Spring Monitoring Data

Well No	CS10			DS01			CS08			SCM-7			SCM-15								
GS—MP																					
Date	FLOW GPM	pH	SC	FLOW GPM	pH	SC	Flow	pH	SC	Flow GPM	pH	SC	Flow GPM	pH	SC	SWL	SC	Temp	SWL	SC	Temp
6/1-6/3/80		DRY		--	--	--															
9/21/80		DRY		40																	
3/5/81		DRY			DRY		Dry														
5/28/81	80	2.29	6800																		
8/18/81	14.1	2.55	1059																		
2/5/82	0.3	1.50	10545																		
12/30/82																					
3/6/83				6.0	2.80	2283	Dry			13.7	2.35	4243	3.8	5.55	1100						

A-2

SPRING WATER QUALITY LABORATORY ANALYSES

```
MONTANA BUREAU OF MINES AND GEOLOGY          WATER QUALITY ANALYSIS
BUTTE,MONTANA  59701  (406)496-4101          LAB NO. 0002316

            STATE MONTANA                          COUNTY CASCADE
 LATITUDE-LONGITUDE 47D23'12"N 111D10'49"W    SITE LOCATION 19N  4E 23 ADCD
    UTM COORDINATES 212 NS247890 E486410          MBMG SITE SC-AS01
    TOPOGRAPHIC MAP SOUTHEAST GREAT FALLS 2 1     STATION ID 472312111104501
    GEOLOGIC SOURCE 221MRSN*          *          * SAMPLE SOURCE MINE DRAINAGE
     DRAINAGE BASIN BB                    LAND SURFACE ALTITUDE  3500.  FT   10
   AGENCY & SAMPLER MBMG*JJD                SUSTAINED YIELD
      BOTTLE NUMBER AS-01                   YIELD MEAS METHOD
        DATE SAMPLED 20-SEP 80              TOTAL DEPTH OF WELL
        TIME SAMPLED 09:00 HOURS     SWL ABOVE( ) OR BELOW GS
      LAB & ANALYST MBMG*ENA                CASING DIAMETER
      DATE ANALYZED 09-MAR-81                 CASING TYPE
     SAMPLE HANDLING 4120                  COMPLETION TYPE    *
      METHOD SAMPLED GRAB                PERFORATION INTERVAL
          WATER USE UNUSED

     SAMPLING SITE SAND COULEE MINING DISTRICT*NO NAME CREEK
    GEOLOGIC SOURCE MORRISON FORMATION

                      MG/L      MEQ/L                              MG/L      MEQ/L
  CALCIUM    (CA)      190.      9.48 BICARBONATE    (HCO3)
  MAGNESIUM  (MG)      122.     10.04 CARBONATE      (CO3)
  SODIUM     (NA)       19.4     0.84 CHLORIDE       (CL)          5.1      0.02
  POTASSIUM  (K)          .3     0.01 SULFATE        (SO4)      4600.      95.77
  IRON       (FE)      712.     38.25 NITRATE       (AS N)        .01      0.00
  MANGANESE  (MN)       2.03     0.07 FLUORIDE       (F)          1.20      0.22
  SILICA     (SIO2)    88.0           PHOSPHATE TOT (AS P)

    TOTAL CATIONS                58.69          TOTAL ANIONS                96.08

    STANDARD DEVIATION OF ANION-CATION BALANCE   (SIGMA)

            LABORATORY PH      2.70    TOTAL HARDNESS AS CACO3    976.50
    FIELD WATER TEMPERATURE   10.0 C  TOTAL ALKALINITY AS CACO3
 CALCULATED DISSOLVED SOLIDS            SODIUM ADSORPTION RATIO      0.27
    SUM OF DISS. CONSTITUENT             RYZNAR STABILITY INDEX
LAB SPEC.COND.(MICROMHOS/CM)  4568.    LANGLIER SATURATION INDEX

      PARAMETER                VALUE      PARAMETER                VALUE
TEMPERATURE, AIR (C)          13.0 C   CNDUCTVY,FIELD MICROMHOS    5102.
FIELD PH                       2.62    ALUMINUM, DISS (MG/L-AL)     393.
NICKEL,DISS (MG/L AS NI)       3.96    SILVER,DISS (MG/L AS AG)       .002
LEAD,DISS  (MG/L AS PB)        <.04    BORON ,DISS (MG/L AS B)        .16
STRONTIUM,DISS (MG/L-SR)       .95     CADMIUM,DISS(MG/L AS CD)       .041
TITANIUM DIS(MG/L AS TI)       .065    CHROMIUM, DISS (MG/L-CR)       .27
VANADIUM,DISS(MG/L AS V)       .34     COPPER,DISS (MG/L AS CU)       .15
ZINC,DISS  (MG/L AS ZN)      17.6      LITHIUM,DISS(MG/L AS LI)       .52
ZIRCONIUM DIS(MG/L AS ZR       .040    MOLYBDENUM,DISS(MG/L-MO)       .03
ARSENIC,DISS(UG/L AS AS)      30.4     MERCURY,DISS(UG/L AS HG)       .03
SELENIUM, DISS (UG/L-SE)       1.7     ACIDITY,TOT(MG/L-CACO3)    4695.


REMARKS: FINE WHITE PRECIPITATE IN WATER -BECOMES ORANGE PRECIPITATE UPON
         REACHING CREEK * MINE OUTFLOW - HEAD OF NO-NAME COULEE (SITE AS-01) *
    LAB: H+=41.1 MG/L * 40.7 MEQV/L, SIGMA -10.3, 114 TOTAL CATION MEQVS/L *


EXPLANATION:  MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L =
MILLIEQUIVELENTS PER LITER.  FT = FEET, MT = METERS.  (M) = MEASURED, (E) =
ESTIMATED, (R) = REPORTED.  TR = TOTAL RECOVERABLE.  TOT = TOTAL.

                        QW  WA  SS  WI  OW  PW  AT      OTHER
OTHER AVAILABLE DATA
OTHER FILE NUMBERS:

         PROJECT:                              COST:
   LAST EDIT DATE:  04-MAY-81                   BY:  TF *CLG
PROCESSING PROGRAM:  F1730F V2 (11/3/81)     PRINTED:  27-MAY-83

                  PERCENT MEQ/L (FOR PIPER PLOT)
                CA    MG    NA    K    CL   SO4 HCO3  CO3
              46.5 49.3   4.1   0.0  0.1 99.9  0.0   0.0

NOTE:  IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER:  0002316
```

MONTANA BUREAU OF MINES AND GEOLOGY
BUTTE,MONTANA 59701 (406)496-4101

WATER QUALITY ANALYSIS
LAB NO. B101006

STATE	MONTANA	COUNTY	CASCADE
LATITUDE-LONGITUDE	47D23'12"N 111D10'49"W	SITE LOCATION	19N 04E 23 ADCB
UTM COORDINATES	712 N5247890 E486410	MBMG SITE	AS01
TOPOGRAPHIC MAP	SOUTHEAST GREAT FALLS 7.1	STATION ID	472312111049O1
GEOLOGIC SOURCE	221MRSN* * *	SAMPLE SOURCE	MINE DRAINAGE
DRAINAGE BASIN	BB	LAND SURFACE ALTITUDE	3500. < 10
AGENCY + SAMPLER	MBMG*ADM	SUSTAINED YIELD	
BOTTLE NUMBER	AS-01	YIELD MEAS METHOD	
DATE SAMPLED	14-JUL-81	TOTAL DEPTH OF WELL	
TIME SAMPLED	11:00 HOURS	SWL ABOVE(-) OR BELOW GS	
LAB + ANALYST	MBMG*FNA	CASING DIAMETER	
DATE ANALYZED		CASING TYPE	
SAMPLE HANDLING	4220	COMPLETION TYPE	*
METHOD SAMPLED	GRAB	PERFORATION INTERVAL	
WATER USE	UNUSED		

SAMPLING SITE SAND COULEE MINING DISTRICT*NO-NAME CREEK
GEOLOGIC SOURCE MORRISON FORMATION

	MG/L	MEQ/L		MG/L	MEQ/L
CALCIUM (CA)	173.	8.63	BICARBONATE (HCO3)	.0	
MAGNESIUM (MG)	122.	10.04	CARBONATE (CO3)	.0	
SODIUM (NA)	16.1	0.70	CHLORIDE (CL)	6.5	0.18
POTASSIUM (K)	.27	0.01	SULFATE (SO4)	4839.	100.75
IRON (FE)	861.	46.25	NITRATE (AS N)	.85	0.06
MANGANESE (MN)	1.95	0.07	FLUORIDE (F)	8.12	0.43
SILICA (SIO2)	71.6		PHOSPHATE TOT (AS P)		
TOTAL CATIONS		65.70	TOTAL ANIONS		101.42

STANDARD DEVIATION OF ANION-CATION BALANCE (SIGMA)

LABORATORY PH	2.56	TOTAL HARDNESS AS CACO3	934.13
FIELD WATER TEMPERATURE	12.1	TOTAL ALKALINITY AS CACO3	
CALCULATED DISSOLVED SOLIDS		SODIUM ADSORPTION RATIO	0.23
SUM OF DISS. CONSTITUENT		RYZNAR STABILITY INDEX	
LAB SPEC.COND.(MICROMHOS/CM)	5157.	LANGLIER SATURATION INDEX	

PARAMETER	VALUE	PARAMETER	VALUE
TEMPERATURE, AIR (C)	20.0	CNDUCTVY,FIELD MICROMHOS	5357.
FIELD PH	2.71	ALUMINUM, DISS (MG/L-AL)	463.
NICKEL,DISS (MG/L AS NI)	4.32	SILVER,DISS (MG/L AS AG)	<.002
LEAD,DISS (MG/L AS PB)	<.004	BORON ,DISS (MG/L AS B)	.27
STRONTIUM,DISS (MG/L-SR)	.93	CADMIUM,DISS(MG/L AS CD)	.084
TITANIUM DIS(MG/L AS TI)	.024	CHROMIUM, DISS (MG/L-CR)	.26
VANADIUM,DISS(MG/L AS V)	.35	COPPER,DISS (MG/L AS CU)	.31
ZINC,DISS (MG/L AS ZN)	18.7	LITHIUM,DISS(MG/L AS LI)	.52
ZIRCONIUM DIS(MG/L AS ZR	<.004	MOLYBDENUM,DISS(MG/L-MO)	<.02
IRON,TR (MG/L AS FE)	865.	SELENIUM,TR (UG/L AS SE)	2.4
ALUMINUM,TR (MG/L AS AL)	466.	ACIDITY,TOT(MG/L-CACO3)	4060.

REMARKS: WATER VERY FROTHY AND FOAM COVERED AFTER DISCHARGE
MINE OUT FLOW, HEAD OF NO-NAME COULEE (SITE AS-01)
MN OF 81.73 MG/L GIVES 100.5 MEQ CATIONS GIVES .6 SIGMA

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L = MILLIEQUIVELENTS PER LITER, FT = FEET, MT = METERS. (M) = MEASURED, (E) = ESTIMATED, (R) = REPORTED. TR = TOTAL RECOVERABLE. TOT = TOTAL.

	QW	WA	SO	WI	OW	PW	AT	OTHER
OTHER AVAILABLE DATA	Y							
OTHER FILE NUMBERS:	80Q2316							

PROJECT:		COST:	
LAST EDIT DATE:	19-FEB-82	BY:	TP *JKS
PROCESSING PROGRAM:	F1730P V2 (11/3/81)	PRINTED:	27-MAY-83

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
44.6	51.8	3.6	0.0	0.2	99.8	0.0	0.0

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: B101006

MONTANA BUREAU OF MINES AND GEOLOGY
BUTTE,MONTANA 59701 (406)496-4101

WATER QUALITY ANALYSIS
LAB NO. 8002317

STATE	MONTANA	COUNTY	CASCADE
LATITUDE-LONGITUDE	47D23'21"N 111D10'38"W	SITE LOCATION	19N 4E 23 AADC
UTM COORDINATES	12 N5248190 E486595	MRMG SITE	AS-02
TOPOGRAPHIC MAP	SOUTHEAST GREAT FALLS 7 1	STATION ID	472321111103801
GEOLOGIC SOURCE	221MRSN* * *	SAMPLE SOURCE	MINE DRAINAGE
DRAINAGE BASIN	BB	LAND SURFACE ALTITUDE	3570. FT . 10
AGENCY + SAMPLER	MBMG*JJD	SUSTAINED YIELD	
BOTTLE NUMBER	AS-02	YIELD MEAS METHOD	
DATE SAMPLED	20-SEP-80	TOTAL DEPTH OF WELL	
TIME SAMPLED	09:30 HOURS	SWL ABOVE(-) OR BELOW GS	
LAB + ANALYST	MBMG*ENA	CASING DIAMETER	
DATE ANALYZED	09-MAR-81	CASING TYPE	
SAMPLE HANDLING	4130	COMPLETION TYPE	*
METHOD SAMPLED	GRAB	PERFORATION INTERVAL	
WATER USE	UNUSED		

SAMPLING SITE SAND COULEE MINING DISTRICT*NO NAME CREEK
GEOLOGIC SOURCE MORRISON FORMATION

	MG/L	MEQ/L		MG/L	MEQ/L
CALCIUM (CA)	190.	9.48	BICARBONATE (HCO3)		
MAGNESIUM (MG)	118.	9.71	CARBONATE (CO3)		
SODIUM (NA)	15.9	0.69	CHLORIDE (CL)	2.5	0.07
POTASSIUM (K)	<.15		SULFATE (SO4)	5400.	112.43
IRON (FE)	502.	26.97	NITRATE (AS N)	<.01	
MANGANESE (MN)	2.54	0.09	FLUORIDE (F)	4.97	0.26
SILICA (SIO2)	104.0		PHOSPHATE TOT (AS P)		
TOTAL CATIONS		46.94	TOTAL ANIONS		112.76

STANDARD DEVIATION OF ANION-CATION BALANCE (SIGMA)

LABORATORY PH	2.49	TOTAL HARDNESS AS CACO3	960.12
FIELD WATER TEMPERATURE	9.6 C	TOTAL ALKALINITY AS CACO3	
CALCULATED DISSOLVED SOLIDS		SODIUM ADSORPTION RATIO	0.22
SUM OF DISS. CONSTITUENT		RYZNAR STABILITY INDEX	
LAB SPEC.COND.(MICROMHOS/CM)	5292.	LANGLIER SATURATION INDEX	

PARAMETER	VALUE	PARAMETER	VALUE
TEMPERATURE, AIR (C)	14.0 C	CNDUCTVY,FIELD MICROMHOS	5689.
FIELD PH	2.46	ALUMINUM, DISS (MG/L-AL)	481.
NICKEL,DISS (MG/L AS NI)	4.6	SILVER,DISS (MG/L AS AG)	<.002
LEAD,DISS (MG/L AS PB)	<.04	BORON ,DISS (MG/L AS B)	.19
STRONTIUM,DISS (MG/L-SR)	.74	CADMIUM,DISS(MG/L AS CD)	.11
TITANIUM DIS(MG/L AS TI)	.069	CHROMIUM, DISS (MG/L-CR)	.20
VANADIUM,DISS(MG/L AS V)	.15	COPPER,DISS (MG/L AS CU)	.23
ZINC,DISS (MG/L AS ZN)	19.5	LITHIUM,DISS(MG/L AS LI)	.63
ZIRCONIUM DIS(MG/L AS ZR	.030	MOLYBDENUM,DISS(MG/L-MO)	.03
ARSENIC,DISS(UG/L AS AS)	<.1	MERCURY,DISS(UG/L AS HG)	<.03
SELENIUM, DISS (UG/L-SE)	1.4	ACIDITY,TOT(MG/L-CACO3)	4560.

REMARKS: WATER IS PALE YELLOW - BECOMES ORANGE UPON REACHING CREEK * SPRING DRAINAGE FROM MINE ADIT AS-02 * JUST ABOVE LANDFILL - SAND COULEE * DISCHARGE FROM ADIT (CAVED) AND OLD WOOD DRAIN PIPE *
LAB: MH=46.6 MG/L * 46.2 MEQVS/L, SIGMA .97, 111.0 TOTAL CATION MEQVS/L *

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L = MILLIEQUIVELENTS PER LITER. FT = FEET, MT = METERS. (M) = MEASURED, (E) = ESTIMATED, (R) = REPORTED. TR = TOTAL RECOVERABLE. TOT = TOTAL.

QW WA S2 WI OW PW AT OTHER

OTHER AVAILABLE DATA
OTHER FILE NUMBERS:

PROJECT:		COST:	
LAST EDIT DATE:	04-MAY-81	BY:	TP *CLC
PROCESSING PROGRAM:	F1730P V2 (11/3/81)	PRINTED:	27-MAY-83

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
47.7	48.8	3.5	0.0	0.1	99.9	0.0	0.0

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: 8002317

MONTANA BUREAU OF MINES AND GEOLOGY
BUTTE, MONTANA 59701 (406)496-4101

WATER QUALITY ANALYSIS
LAB NO. B002318

STATE	MONTANA	COUNTY	CASCADE
LATITUDE-LONGITUDE	47D23'20"N 111D10'32"W	SITE LOCATION	19N 4E 23 AADD
UTM COORDINATES	Z12 N5248180 E436755	MBMG SITE	AS-03
TOPOGRAPHIC MAP	SOUTHEAST GREAT FALLS 7 1	STATION ID	472320111103201
GEOLOGIC SOURCE	221NRSN*111LNFL*	* SAMPLE SOURCE	MINE DRAINAGE
DRAINAGE BASIN	BB	LAND SURFACE ALTITUDE	3530. FT < 10
AGENCY & SAMPLER	MBMG*JJD	SUSTAINED YIELD	
BOTTLE NUMBER	AS 03	YIELD MEAS METHOD	
DATE SAMPLED	20-SEP-80	TOTAL DEPTH OF WELL	
TIME SAMPLED	10:00 HOURS	SWL ABOVE(-) OR BELOW GS	
LAB & ANALYST	MBMG*ENA	CASING DIAMETER	
DATE ANALYZED	09-MAR-81	CASING TYPE	
SAMPLE HANDLING	4120	COMPLETION TYPE	*
METHOD SAMPLED	GRAB	PERFORATION INTERVAL	
WATER USE	UNUSED		

SAMPLING SITE SAND COULEE MINING DISTRICT*NO-NAME CREEK
GEOLOGIC SOURCE MORRISON FORMATION

	MG/L	MEQ/L		MG/L	MEQ/L
CALCIUM (CA)	426.	21.26	BICARBONATE (HCO3)		
MAGNESIUM (MG)	186.	15.30	CARBONATE (CO3)		
SODIUM (NA)	20.2	0.88	CHLORIDE (CL)	5.8	0.16
POTASSIUM (K)	<.15		SULFATE (SO4)	6520.	135.75
IRON (FE)	674.	36.21	NITRATE (AS N)	.04	0.00
MANGANESE (MN)	9.67	0.35	FLUORIDE (F)	6.7	0.35
SILICA (SIO2)	117.0		PHOSPHATE TOT (AS P)		
TOTAL CATIONS		74.00	TOTAL ANIONS		136.27

STANDARD DEVIATION OF ANION-CATION BALANCE (SIGMA)

LABORATORY PH	2.65	TOTAL HARDNESS AS CACO3	1829.30
FIELD WATER TEMPERATURE	13.8 C	TOTAL ALKALINITY AS CACO3	
CALCULATED DISSOLVED SOLIDS		SODIUM ADSORPTION RATIO	0.21
SUM OF DISS. CONSTITUENT		RYZNAR STABILITY INDEX	
LAB SPEC.COND.(MICROMHOS/CM)	5726.	LANGLIER SATURATION INDEX	

PARAMETER	VALUE	PARAMETER	VALUE
TEMPERATURE, AIR (C)	14.0 C	CNDUCTVY,FIELD MICROMHOS	5414.
FIELD PH	2.62	ALUMINUM, DISS (MG/L-AL)	552.
NICKEL,DISS (MG/L AS NI)	5.31	SILVER,DISS (MG/L AS AG)	.006
LEAD,DISS (MG/L AS PB)	<.04	BORON ,DISS (MG/L AS B)	.29
STRONTIUM,DISS (MG/L-SR)	1.26	CADMIUM,DISS(MG/L AS CD)	.057
TITANIUM DIS(MG/L AS TI)	.11	CHROMIUM, DISS (MG/L-CR)	.20
VANADIUM,DISS(MG/L AS V)	.06	COPPER,DISS (MG/L AS CU)	.059
ZINC,DISS (MG/L AS ZN)	21.1	LITHIUM,DISS(MG/L AS LI)	.78
ZIRCONIUM DIS(MG/L AS ZR	.041	MOLYBDENUM,DISS(MG/L-MO)	<.02
ARSENIC,DISS(UG/L AS AS)	<.1	MERCURY,DISS(UG/L AS HG)	<.03
SELENIUM, DISS (UG/L-SE)	1.2	ACIDITY,TOT(MG/L-CACO3)	4675.

REMARKS: WATER IS PALE ORANGE - BECOMES BRIGHT RED UPON REACHING CREEK *
SPRING AS-03 - FLOWING THRU SAND COULEE LANDFILL *
SAMPLE TAKEN JUST BELOW LANDFILL *
LAB: MH=36.7 MG/L * 36.4 MEQV/L, SIGMA .65 * 130 TOTAL CATION MEQVS/L *

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L = MILLIEQUIVELENTS PER LITER. FT = FEET, MT = METERS. (M) = MEASURED, (E) = ESTIMATED, (R) = REPORTED. TR = TOTAL RECOVERABLE. TOT = TOTAL.

	GW	WA	SS	WI	OW	PW	AT	OTHER
OTHER AVAILABLE DATA								
OTHER FILE NUMBERS:								

PROJECT:		COST:	
LAST EDIT DATE:	04-MAY-81	BY:	TP *CLC
PROCESSING PROGRAM:	F1730P V2 (11/3/81)	PRINTED:	27-MAY-83

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
56.8	40.9	2.3	0.0	0.1	99.9	0.0	0.0

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: B002318

MONTANA BUREAU OF MINES AND GEOLOGY
BUTTE, MONTANA 59701 (406)496 4101

WATER QUALITY ANALYSIS
LAB NO. 8100057

STATE	MONTANA	COUNTY	CASCADE
LATITUDE-LONGITUDE	47D03'14"N 111D10'30"W	SITE LOCATION	19N 4E 23 ABAC
UTM COORDINATES	Z12 N5247990 E486620	MBMG SITE NO	03
TOPOGRAPHIC MAP	SOUTHEAST GREAT FALLS 7.5	STATION ID	472314111103901
GEOLOGIC SOURCE	221MRSN* * *	SAMPLE SOURCE	MINE DRAINAGE
DRAINAGE BASIN	BB	LAND SURFACE ALTITUDE	3570. FT ± 50
AGENCY & SAMPLER	MBMG*JJB	SUSTAINED YIELD	
BOTTLE NUMBER	AS-03	YIELD MEAS METHOD	
DATE SAMPLED	03-MAR-81	TOTAL DEPTH OF WELL	
TIME SAMPLED	11:00 HOURS	SWL ABOVE(-) OR BELOW	GS
LAB & ANALYST	MBMG*ENA	CASING DIAMETER	
DATE ANALYZED	22-APR-81	CASING TYPE	
SAMPLE HANDLING	4120	COMPLETION TYPE	*
METHOD SAMPLED	GRAB	PERFORATION INTERVAL	
WATER USE	UNUSED		

SAMPLING SITE STOCKETT - SAND COULEE MINING DISTRICT
GEOLOGIC SOURCE MORRISON FORMATION

	MG/L	MEQ/L		MG/L	MEQ/L
CALCIUM (CA)	292.	14.57	BICARBONATE (HCO3)		
MAGNESIUM (MG)	190.	15.63	CARBONATE (CO3)		
SODIUM (NA)	17.1	0.74	CHLORIDE (CL)	2.0	0.06
POTASSIUM (K)	1.1	0.03	SULFATE (SO4)	7700.	160.31
IRON (FE)	944.	50.71	NITRATE (AS N)	1.70	0.12
MANGANESE (MN)	2.84	0.10	FLUORIDE (F)	12.8	0.67
SILICA (SIO2)	116.0		PHOSPHATE TOT (AS P)		
TOTAL CATIONS		81.79	TOTAL ANIONS		161.17

STANDARD DEVIATION OF ANION-CATION BALANCE (SIGMA)

LABORATORY PH	2.77	TOTAL HARDNESS AS CACO3	1511.16
FIELD WATER TEMPERATURE	8.1 C	TOTAL ALKALINITY AS CACO3	
CALCULATED DISSOLVED SOLIDS		SODIUM ADSORPTION RATIO	0.19
SUM OF DISS. CONSTITUENT		RYZNAR STABILITY INDEX	
LAB SPEC.COND.(MICROMHOS/CM)	6710.	LANGLIER SATURATION INDEX	

PARAMETER	VALUE	PARAMETER	VALUE
TEMPERATURE, AIR (C)	10. C	CNDUCTVY,FIELD MICROMHOS	8510.
FIELD PH	3.38	ALUMINUM,TR (MG/L AS AL)	752.
ARSENIC,TR (UG/L AS AS)	<2.1	IRON,TR (MG/L AS FE)	1210.
SELENIUM,TR (UG/L AS SE)	.8	ACIDITY,TOT(MG/L-CACO3)	6002.
ALUMINUM, DISS (MG/L-AL)	579.	NICKEL,DISS (MG/L AS NI)	5.18
SILVER,DISS (MG/L AS AG)	.02	LEAD,DISS (MG/L AS PB)	<.04
BORON ,DISS (MG/L AS B)	.22	STRONTIUM,DISS (MG/L-SR)	1.16
CADMIUM,DISS(MG/L AS CD)	.079	TITANIUM DIS(MG/L AS TI)	.083
CHROMIUM, DISS (MG/L-CR)	.252	VANADIUM,DISS(MG/L AS V)	.226
COPPER,DISS (MG/L AS CU)	.144	ZINC,DISS (MG/L AS ZN)	21.5
LITHIUM,DISS(MG/L AS LI)	.651	ZIRCONIUM DIS(MG/L AS ZR	.061
MOLYBDENUM,DISS(MG/L-MO)	.83	ARSENIC,DISS(UG/L AS AS)	<2.1
SELENIUM, DISS (UG/L-SE)	.5		

REMARKS: WATER TURBID-FILTERS CLEAR*ORGANIC MATTER: AL-HYDROXIDE IN FILTERATE *
SAMPLE TAKEN AT ADIT MOUTH - ABOVE SAND COULEE LANDFILL *
LAB: 150.0 TOTAL CATION MEQVS, 2.95 SIGMA, EST HT 48 MG/L *

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L = MILLIEQUIVELENTS PER LITER, FT = FEET, MT = METERS, (M) = MEASURED, (E) = ESTIMATED, (R) = REPORTED. TR = TOTAL RECOVERABLE. TOT = TOTAL.

QW WA S2 WI OW PW AT OTHER

OTHER AVAILABLE DATA
OTHER FILE NUMBERS:

PROJECT:		COST:	
LAST EDIT DATE:	22-APR-81	BY:	TP *CLC
PROCESSING PROGRAM:	F1730P V2 (11/3/81)	PRINTED:	22-MAY 83

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
47.0	50.5	2.4	0.1	0.0	100.0	0.0	0.0

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: 8100057

MONTANA BUREAU OF MINES AND GEOLOGY
BUTTE,MONTANA 59701 (406)496-4101

WATER QUALITY ANALYSIS
LAB NO. 8002319

STATE	MONTANA	COUNTY	CASCADE
LATITUDE-LONGITUDE	47D23'34"N 111D10'46"W	SITE LOCATION	19N 4E 14 DDCD
UTM COORDINATES	Z12 N5248670 E486570	MBMG SITE	AS-04
TOPOGRAPHIC MAP	SOUTHEAST GREAT FALLS 7 1	STATION ID	472334111104601
GEOLOGIC SOURCE	221MRSN* *	SAMPLE SOURCE	MINE DRAINAGE
DRAINAGE BASIN	BB	LAND SURFACE ALTITUDE	3540. FT < 50
AGENCY & SAMPLER	MBMG*JJD	SUSTAINED YIELD	
BOTTLE NUMBER	AS-04	YIELD MEAS METHOD	
DATE SAMPLED	20-SEP-80	TOTAL DEPTH OF WELL	
TIME SAMPLED	12:00 HOURS	SWL ABOVE(-) OR BELOW GS	
LAB & ANALYST	MBMG*ENA	CASING DIAMETER	
DATE ANALYZED	09-MAR-81	CASING TYPE	
SAMPLE HANDLING	4120	COMPLETION TYPE	*
METHOD SAMPLED	GRAB	PERFORATION INTERVAL	
WATER USE	UNUSED		

SAMPLING SITE SAND COULEE MINING DISTRICT*NO-NAME CREEK
GEOLOGIC SOURCE MORRISON FORMATION

	MG/L	MEQ/L		MG/L	MEQ/L
CALCIUM (CA)	171.	8.53	BICARBONATE (HCO3)		
MAGNESIUM (MG)	133.	10.94	CARBONATE (CO3)		
SODIUM (NA)	23.5	1.02	CHLORIDE (CL)	4.9	0.14
POTASSIUM (K)	4.4	0.11	SULFATE (SO4)	3560.	74.12
IRON (FE)	436.	23.40	NITRATE (AS N)	<.02	
MANGANESE (MN)	1.63	0.06	FLUORIDE (F)	3.31	0.17
SILICA (SIO2)	54.5		PHOSPHATE TOT (AS P)		
TOTAL CATIONS		44.09	TOTAL ANIONS		74.43

STANDARD DEVIATION OF ANION-CATION BALANCE (SIGMA)

LABORATORY PH	3.04	TOTAL HARDNESS AS CACO3	974.42
FIELD WATER TEMPERATURE	12.0 C	TOTAL ALKALINITY AS CACO3	
CALCULATED DISSOLVED SOLIDS		SODIUM ADSORPTION RATIO	0.33
SUM OF DISS. CONSTITUENT		RYZNAR STABILITY INDEX	
LAB SPEC.COND.(MICROMHOS/CM)	3638.	LANGLIER SATURATION INDEX	

PARAMETER	VALUE	PARAMETER	VALUE
TEMPERATURE, AIR (C)	14. C	CNDUCTVY,FIELD MICROMHOS	3329.
FIELD PH	3.84	ALUMINUM, DISS (MG/L-AL)	243.
NICKEL,DISS (MG/L AS NI)	2.10	SILVER,DISS (MG/L AS AG)	<.002
LEAD,DISS (MG/L AS PB)	<.04	BORON ,DISS (MG/L AS B)	.07
STRONTIUM,DISS (MG/L-SR)	1.02	CADMIUM,DISS(MG/L AS CD)	.027
TITANIUM DIS(MG/L AS TI)	.052	CHROMIUM, DISS (MG/L-CR)	.064
VANADIUM,DISS(MG/L AS V)	.14	COPPER,DISS (MG/L AS CU)	.041
ZINC,DISS (MG/L AS ZN)	8.34	LITHIUM,DISS(MG/L AS LI)	.57
ZIRCONIUM DIS(MG/L AS ZR	.028	MOLYBDENUM,DISS(MG/L-MO)	.03
ARSENIC,DISS(UG/L AS AS)	40.5	MERCURY,DISS(UG/L AS HG)	<.03
SELENIUM, DISS (UG/L-SE)	.5	ACIDITY,TOT(MG/L-CACO3)	2077.

REMARKS: WATER IS TURBID - MILKY - BECOMES ORANGE UPON REACHING CREEK *
KATE'S COULEE AT MINE ADIT (SITE AS-04) * ABOVE OLSON HOUSE *
SAMPLE TAKEN AT TOP POOL OUTSIDE ADIT - FLOW JUST BELOW *
LAB: H4=9.1 MG/L, SIGMA 5.54, TOTAL CATION MEQVS/L 52 *

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L = MILLIEQUIVELENTS PER LITER. FT = FEET, MT = METERS. (M) = MEASURED, (E) = ESTIMATED, (R) = REPORTED. TR = TOTAL RECOVERABLE. TOT = TOTAL.

OW WA SS WI OW PW AT OTHER

OTHER AVAILABLE DATA
OTHER FILE NUMBERS:

PROJECT:		COST:	
LAST EDIT DATE:	04-MAY-81	BY:	TP *CLC
PROCESSING PROGRAM:	F1730P V2 (11/3/81)	PRINTED:	27-MAY-83

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
41.4	53.1	5.0	0.5	0.2	99.8	0.0	0.0

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: 8002319

MONTANA BUREAU OF MINES AND GEOLOGY — WATER QUALITY ANALYSIS
BUTTE, MONTANA 59701 (406)496 4101 — LAB NO. 8100050

STATE MONTANA — COUNTY CASCADE
LATITUDE-LONGITUDE 47D23'34"N 111D10'43"W — SITE LOCATION 19N 4E 14 BBCB
UTM COORDINATES 712 N5218600 E486505 — MBMG SITE AS 04
TOPOGRAPHIC MAP SOUTHEAST GREAT FALLS 7 1 — STATION ID 472334111104301
GEOLOGIC SOURCE 221MRSN* * * SAMPLE SOURCE MINE DRAINAGE
DRAINAGE BASIN BB — LAND SURFACE ALTITUDE 3560. FT 50
AGENCY + SAMPLER MBMG*JJD — SUSTAINED YIELD
BOTTLE NUMBER AS-04 — YIELD MEAS METHOD
DATE SAMPLED 03-MAR-81 — TOTAL DEPTH OF WELL
TIME SAMPLED 08:30 HOURS SWI — ABOVE( ) OR BELOW OS
LAB + ANALYST MBMG*ENA — CASING DIAMETER
DATE ANALYZED 22-APR-81 — CASING TYPE
SAMPLE HANDLING 4120 — COMPLETION TYPE *
METHOD SAMPLED GRAB — PERFORATION INTERVAL
WATER USE UNUSED

SAMPLING SITE STOCKETT SAND COULEE MINING DISTRICT
GEOLOGIC SOURCE MORRISON FORMATION

	MG/L	MEQ/L			MG/L	MEQ/L
CALCIUM (CA)	169.	8.43	BICARBONATE	(HCO3)		
MAGNESIUM (MG)	138.	11.35	CARBONATE	(CO3)		
SODIUM (NA)	22.6	0.98	CHLORIDE	(CL)	5.3	0.15
POTASSIUM (K)	4.7	0.12	SULFATE	(SO4)	3222.	67.08
IRON (FE)	466.	25.03	NITRATE	(AS N)	.05	0.06
MANGANESE (MN)	1.59	0.06	FLUORIDE	(F)	3.02	0.16
SILICA (SIO2)	51.2		PHOSPHATE TOT	(AS P)		
TOTAL CATIONS		45.98	TOTAL ANIONS			67.45

STANDARD DEVIATION OF ANION-CATION BALANCE (SIGMA)

LABORATORY PH	3.00	TOTAL HARDNESS AS CACO3	990.00
FIELD WATER TEMPERATURE	11.0 C	TOTAL ALKALINITY AS CACO3	
CALCULATED DISSOLVED SOLIDS		SODIUM ADSORPTION RATIO	0.31
SUM OF DISS. CONSTITUENT		RYZNAR STABILITY INDEX	
LAB SPEC.COND.(MICROMHOS/CM)	3573.	LANGLIER SATURATION INDEX	

PARAMETER	VALUE	PARAMETER	VALUE
TEMPERATURE, AIR (C)	8. C	CNDUCTVY,FIELD MICROMHOS	4105.
FIELD PH	3.98	ALUMINUM,TR (MG/L AS AL)	456.
IRON,TR (MG/L AS FE)	1.56	ACIDITY,TOT(MG/L-CACO3)	2315.
ARSENIC,TR (UG/L AS AS)	41.1	SELENIUM,TR (UG/L AS SE)	.4
ALUMINUM, DISS (MG/L-AL)	248.	NICKEL,DISS (MG/L AS NI)	2.12
SILVER,DISS (MG/L AS AG)	.023	LEAD,DISS (MG/L AS PB)	<.04
BORON ,DISS (MG/L AS B)	.24	STRONTIUM,DISS (MG/L-SR)	1.15
CADMIUM,DISS(MG/L AS CD)	.027	TITANIUM DIS(MG/L AS TI)	.049
CHROMIUM, DISS (MG/L-CR)	.067	VANADIUM,DISS(MG/L AS V)	.168
COPPER,DISS (MG/L AS CU)	.026	ZINC,DISS (MG/L AS ZN)	8.19
LITHIUM,DISS(MG/L AS LI)	.55	ZIRCONIUM DIS(MG/L AS ZR	.050
MOLYBDENUM,DISS(MG/L-MO)	.19	ARSENIC,DISS(UG/L AS AS)	39.0
SELENIUM, DISS (UG/L-SE)	.4		

REMARKS: SAMPLE CLEAR - LITTLE FILTERATE *
SAMPLE TAKEN AT MINE ADIT ABOVE J. OLSON HOME *
COLD WATER UPSTREAM S.C.=1266 DOWNSTREAM 3813 *
LAB: 67.1 CATION MEQVS,.15 SIGMA, 32.9 MG/L EST NI *

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L = MILLIEQUIVELENTS PER LITER. FT = FEET, MI = METERS. (M) = MEASURED, (E) = ESTIMATED, (R) = REPORTED. TR = TOTAL RECOVERABLE. TOT = TOTAL.

QW WA S2 WI GW PW AT OTHER

OTHER AVAILABLE DATA
OTHER FILE NUMBERS:

PROJECT: — COST:
LAST EDIT DATE: 22-APR-81 — BY: TP *CLC
PROCESSING PROGRAM: F1730F V2 (11/3/81) — PRINTED: 27 MAY-83

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
40.4	54.3	4.7	0.6	0.2	99.8	0.0	0.0

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: 8100050

MONTANA BUREAU OF MINES AND GEOLOGY — WATER QUALITY ANALYSIS
BUTTE, MONTANA 59701 (406)496-4101 — LAB NO. 8101087

STATE	MONTANA	COUNTY	CASCADE
LATITUDE-LONGITUDE	47D23'34"N 111D10'46"W	SITE LOCATION	19N 04E 14 DDCD
UTM COORDINATES	Z12 N5248670 E486570	MBMG SITE	AS04
TOPOGRAPHIC MAP	SOUTHEAST GREAT FALLS 7 1	STATION ID	472334111104601
GEOLOGIC SOURCE	221MRSN* *	SAMPLE SOURCE	MINE DRAINAGE
DRAINAGE BASIN	BB	LAND SURFACE ALTITUDE	3540. FT < 50
AGENCY & SAMPLER	MBMG*ABM	SUSTAINED YIELD	
BOTTLE NUMBER	AS04	YIELD MEAS METHOD	
DATE SAMPLED	15-JUL-81	TOTAL DEPTH OF WELL	
TIME SAMPLED	14:00 HOURS	SWL ABOVE(-) OR BELOW GS	
LAB & ANALYST	MBMG*ENA	CASING DIAMETER	
DATE ANALYZED		CASING TYPE	
SAMPLE HANDLING	4220	COMPLETION TYPE	*
METHOD SAMPLED	GRAB	PERFORATION INTERVAL	
WATER USE	UNUSED		

SAMPLING SITE SAND COULEE MINING DISTRICT*NO-NAME CREEK
GEOLOGIC SOURCE MORRISON FORMATION

		MG/L	MEQ/L			MG/L	MEQ/L
CALCIUM	(CA)	161.	8.03	BICARBONATE	(HCO3)	.0	
MAGNESIUM	(MG)	118.	9.71	CARBONATE	(CO3)	.0	
SODIUM	(NA)	17.7	0.77	CHLORIDE	(CL)	9.1	0.26
POTASSIUM	(K)	1.6	0.04	SULFATE	(SO4)	2918.	60.75
IRON	(FE)	568.	30.51	NITRATE	(AS N)	.32	0.02
MANGANESE	(MN)	2.00	0.07	FLUORIDE	(F)	3.57	0.19
SILICA	(SIO2)	62.1		PHOSPHATE TOT	(AS P)		

TOTAL CATIONS 49.14 — TOTAL ANIONS 61.22

STANDARD DEVIATION OF ANION-CATION BALANCE (SIGMA)

LABORATORY PH	3.63	TOTAL HARDNESS AS CACO3	887.71
FIELD WATER TEMPERATURE	13.7	TOTAL ALKALINITY AS CACO3	
CALCULATED DISSOLVED SOLIDS		SODIUM ADSORPTION RATIO	0.26
SUM OF DISS. CONSTITUENT		RYZNAR STABILITY INDEX	
LAB SPEC.COND.(MICROMHOS/CM)	3337.	LANGLIER SATURATION INDEX	

PARAMETER	VALUE	PARAMETER	VALUE
TEMPERATURE, AIR (C)	22. C	CNDUCTVY,FIELD MICROMHOS	3284.
FIELD PH	3.85	ALUMINUM, DISS (MG/L-AL)	346.
NICKEL,DISS (MG/L AS NI)	3.27	SILVER,DISS (MG/L AS AG)	<.002
LEAD,DISS (MG/L AS PB)	<.04	BORON ,DISS (MG/L AS B)	.25
STRONTIUM,DISS (MG/L-SR)	.06	CADMIUM,DISS(MG/L AS CD)	.074
TITANIUM DIS(MG/L AS TI)	.030	CHROMIUM, DISS (MG/L-CR)	.17
VANADIUM,DISS(MG/L AS V)	.15	COPPER,DISS (MG/L AS CU)	.28
ZINC,DISS (MG/L AS ZN)	13.6	LITHIUM,DISS(MG/L AS LI)	.41
ZIRCONIUM DIS(MG/L AS ZR	<.004	MOLYBDENUM,DISS(MG/L-MO)	<.02
IRON,TR (MG/L AS FE)	577.	SELENIUM,TR (UG/L AS SE)	1.8
ALUMINUM,TR (MG/L AS AL)	348.	ACIDITY,TOT(MG/L-CACO3)	1970.

REMARKS: WATER CLEAR BUT GASSY UPON FILTRATION
KATE'S COULEE AT MINE ADIT * SITE AS-04 * ABOVE OLSON HOUSE *
SAMPLE FROM ADIT MOUTH
LAB: RR 39.63 MG/L GIVES 57.9 MEQ CATIONS GIVES 3.3 SIGMA

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L = MILLIEQUIVELENTS PER LITER. FT = FEET, MT = METERS. (M) = MEASURED, (E) = ESTIMATED, (R) = REPORTED. TR = TOTAL RECOVERABLE. TOT = TOTAL.

	QW	WA	S2	WI	OW	PW	AT	OTHER
OTHER AVAILABLE DATA	Y							
OTHER FILE NUMBERS:	80Q2319		8100050					

PROJECT: — COST:
LAST EDIT DATE: 19-FEB 82 — BY: TP *JKS
PROCESSING PROGRAM: F1730P V2 (11/3/81) — PRINTED: 27-MAY-83

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
43.3	52.3	4.2	0.2	0.4	99.6	0.0	0.0

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: 8101087

MONTANA BUREAU OF MINES AND GEOLOGY
BUTTE,MONTANA 59701 (406)496 4101

WATER QUALITY ANALYSIS
LAB NO. 8002320

STATE MONTANA
LATITUDE-LONGITUDE 47D23'34"N 111D10'37"W
UTM COORDINATES ZIO N5240520 E406620
TOPOGRAPHIC MAP SOUTHEAST GREAT FALLS 7.1
GEOLOGIC SOURCE 22IMRSN* *
DRAINAGE BASIN BB
AGENCY & SAMPLER MBMG*JJD
BOTTLE NUMBER AS 05
DATE SAMPLED 20-SEP 00
TIME SAMPLED 12:00 HOURS
LAB & ANALYST MBMG*ENA
DATE ANALYZED 18 FEB 01
SAMPLE HANDLING 4120
METHOD SAMPLED GRAB

WATER USE UNUSED

COUNTY CASCADE
SITE LOCATION 19N 4E 14 BADC
MBMG SITE AS 05
STATION ID 472334111103701
* SAMPLE SOURCE STREAM
LAND SURFACE ALTITUDE 3510. FT 10
WATER FLOW RATE 50. GPM
FLOW MEAS METHOD ESTIMATED
STAGE GAGE
STREAM STAGE
DEPTH TO SAMPLE
TOTAL DEPTH OF WATER
STREAM WIDTH

SAMPLING SITE SAND COULEE MINING DISTRICT*NO NAME CREEK
DRAINAGE BASIN MISSOURI RIVER BETWEEN MARIAS RIVER AND LITTLE PRICKLY PE

		MG/L	MEQ/L			MG/L	MEQ/L
CALCIUM	(CA)	169.	8.43	BICARBONATE	(HCO3)		
MAGNESIUM	(MG)	141.	11.60	CARBONATE	(CO3)		
SODIUM	(NA)	23.9	1.04	CHLORIDE	(CL)	6.0	0.17
POTASSIUM	(K)	4.6	0.12	SULFATE	(SO4)	3150.	65.58
IRON	(FE)	380.	20.41	NITRATE	(AS N)	.03	
MANGANESE	(MN)	1.63	0.06	FLUORIDE	(F)	3.25	0.17
SILICA	(SIO2)	58.0		PHOSPHATE TOT	(AS P)		
TOTAL CATIONS			41.66	TOTAL ANIONS			65.92

STANDARD DEVIATION OF ANION CATION BALANCE (SIGMA)

LABORATORY PH	7.87	TOTAL HARDNESS AS CACO3	1002.35
FIELD WATER TEMPERATURE	14.1 C	TOTAL ALKALINITY AS CACO3	
CALCULATED DISSOLVED SOLIDS		SODIUM ABSORPTION RATIO	0.33
SUM OF DISS. CONSTITUENT		RYZNAR STABILITY INDEX	
LAB SPEC.COND.(MICROMHOS/CM)	3566.	LANGLIER SATURATION INDEX	

PARAMETER	VALUE	PARAMETER	VALUE
TEMPERATURE, AIR (C)	15.0 C	CNDUCTVY,FIELD MICROMHOS	3350.
FIELD PH	3.42	ALUMINUM, DISS (MG/L AL)	242.
NICKEL,DISS (MG/L AS NI)	2.08	SILVER,DISS (MG/L AS AG)	.002
LEAD,DISS (MG/L AS PB)	<.04	BORON ,DISS (MG/L AS B)	.16
STRONTIUM,DISS (MG/L SR)	1.08	CADMIUM,DISS(MG/L AS CD)	.033
TITANIUM DIS(MG/L AS TI)	.040	CHROMIUM, DISS (MG/L CR)	.040
VANADIUM,DISS(MG/L AS V)	.034	COPPER,DISS (MG/L AS CU)	.016
ZINC,DISS (MG/L AS ZN)	0.36	LITHIUM,DISS(MG/L AS LI)	.55
ZIRCONIUM DIS(MG/L AS ZR	.025	MOLYBDENUM,DISS(MG/L MO)	.00
ARSENIC,DISS(UG/L AS AS)	2.5	MERCURY,DISS(UG/L AS HG)	.23
SELENIUM, DISS (UG/L SE)	<.3	ACIDITY,TOT(MG/L CACO3)	2262.

REMARKS: WATER IS BRIGHT ORANGE - BECOMES BLEP RED UPON REACHING CREEK *
SAMPLE TAKEN AT CONFLUENCE OF KATE'S CREEK WITH NO-NAME CREEK FROM
KATE'S CREEK * OWNER REPORTS RAIN CAUSES WHITE PRECIPITATE *
LAB: HH=15.9 MG/L * 15.8 MEQVS/L, SIGMA = .46, 66.4 TOTAL CATION MEQVS/L *

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L =
MILLIEQUIVELENTS PER LITER. FT = FEET, MI = METERS. (M) = MEASURED, (E) =
ESTIMATED, (R) = REPORTED. TR = TOTAL RECOVERABLE. TOT = TOTAL.

OW WA SO WI OW PW AI OTHER

OTHER AVAILABLE DATA
OTHER FILE NUMBERS:

PROJECT:
LAST EDIT DATE: 04 MAY 01
PROCESSING PROGRAM: F1730P V2 (11/3/81)

COST:
BY: JS *CLC
PRINTED: 22 MAY 03

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
39.8	54.7	4.9	0.6	0.3	99.7	0.0	0.0

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: 8002320

MONTANA BUREAU OF MINES AND GEOLOGY
BUTTE,MONTANA 59701 (406)496-4101

WATER QUALITY ANALYSIS
LAB NO. S100059

STATE	MONTANA	COUNTY	CASCADE
LATITUDE-LONGITUDE	47D23'33"N 111D10'38"W	SITE LOCATION	19N 4E 14 DDDC
UTM COORDINATES	ZJJ N5248605 E486605	MBMG SITE	AS-05
TOPOGRAPHIC MAP	SOUTHEAST GREAT FALLS 7 1	STATION ID	472333111103801
GEOLOGIC SOURCE	* * *	SAMPLE SOURCE	STREAM
DRAINAGE BASIN	BB	LAND SURFACE ALTITUDE	3510. FT < 1
AGENCY & SAMPLER	MBMG*JJD	WATER FLOW RATE	150. GPM
BOTTLE NUMBER	AS-05	FLOW MEAS METHOD	ESTIMATED
DATE SAMPLED	03-MAR-81	STAFF GAGE	
TIME SAMPLED	09:00 HOURS	STREAM STAGE	
LAB & ANALYST	MBMG*ENA	DEPTH TO SAMPLE	
DATE ANALYZED	22-APR-81	TOTAL DEPTH OF WATER	
SAMPLE HANDLING	4120	STREAM WIDTH	
METHOD SAMPLED	GRAB		

WATER USE UNUSED

SAMPLING SITE STOCKETT - SAND COULEE MINING DISTRICT
DRAINAGE BASIN MISSOURI RIVER BETWEEN MARIAS RIVER AND LITTLE PRICKLY

	MG/L	MEQ/L		MG/L	MEQ/L
CALCIUM (CA)	99.0	4.94	BICARBONATE (HCO3)		
MAGNESIUM (MG)	79.4	6.53	CARBONATE (CO3)		
SODIUM (NA)	12.8	0.56	CHLORIDE (CL)	6.4	0.18
POTASSIUM (K)	3.4	0.09	SULFATE (SO4)	2854.	59.42
IRON (FE)	186.	9.99	NITRATE (AS N)	.09	0.01
MANGANESE (MN)	.98	0.04	FLUORIDE (F)	2.63	0.14
SILICA (SIO2)	30.6		PHOSPHATE TOT (AS P)		
TOTAL CATIONS		22.14	TOTAL ANIONS		59.75

STANDARD DEVIATION OF ANION-CATION BALANCE (SIGMA)

LABORATORY PH	2.89	TOTAL HARDNESS AS CACO3	574.01
FIELD WATER TEMPERATURE	46.0 C	TOTAL ALKALINITY AS CACO3	
CALCULATED DISSOLVED SOLIDS		SODIUM ADSORPTION RATIO	0.23
SUM OF DISS. CONSTITUENT		RYZNAR STABILITY INDEX	
LAB SPEC.COND.(MICROMHOS/CM)	3319.	LANGLIER SATURATION INDEX	

PARAMETER	VALUE	PARAMETER	VALUE
TEMPERATURE, AIR (C)	8. C	CNDUCTVY,FIELD MICROMHOS	3426.
FIELD PH	3.39	ALUMINUM,TR (MG/L AS AL)	127.
IRON,TR (MG/L AS FE)	192.	ACIDITY,TOT(MG/L-CACO3)	2290.
ARSENIC,TR (UG/L AS AS)	14.4	SELENIUM,TR (UG/L AS SE)	.4
ALUMINUM, DISS (MG/L-AL)	124.	NICKEL,DISS (MG/L AS NI)	1.22
SILVER,DISS (MG/L AS AG)	.06	LEAD,DISS (MG/L AS PB)	.13
BORON ,DISS (MG/L AS B)	.17	STRONTIUM,DISS (MG/L-SR)	.624
CADMIUM,DISS(MG/L AS CD)	.034	TITANIUM DIS(MG/L AS TI)	.025
CHROMIUM, DISS (MG/L-CR)	.063	VANADIUM,DISS(MG/L AS V)	.071
COPPER,DISS (MG/L AS CU)	.050	ZINC,DISS (MG/L AS ZN)	4.47
LITHIUM,DISS(MG/L AS LI)	.305	ZIRCONIUM DIS(MG/L AS ZR	.085
MOLYBDENUM,DISS(MG/L-MO)	.57	ARSENIC,DISS(UG/L AS AS)	14.4
SELENIUM, DISS (UG/L SE)	.3		

REMARKS: WATER IS ORANGE - TURBID * FE-HYDROXIDE PRECIPITATE *
SAMPLE FROM BELOW CULVERT ABOVE JUNCTION WITH STRAIGHT CREEK *
STREAM DRAINAGE FROM ACID SPRING AS-04 * UPSTREAM S.C. 5192 DOWN 41
LAB: 57.9 CATION MEQVS, .95 SIGMA, 42.6 MG/L EST HF *

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L
MILLIEQUIVELENTS PER LITER. FT = FEET, MT = METERS. (M) = MEASURED, (E) =
ESTIMATED, (R) = REPORTED, TR = TOTAL RECOVERABLE. TOT = TOTAL.

	QW	WA	S2	MT	OW	PW	AT	OTHER
OTHER AVAILABLE DATA								
OTHER FILE NUMBERS:								

PROJECT:		COST:	
LAST EDIT DATE:	29-APR 81	BY:	TP *CLC
PROCESSING PROGRAM:	F1730P V2 (11/3/81)	PRINTED:	27-MAY 03

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
40.8	53.9	4.6	0.7	0.3	99.7	0.0	0.0

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: S100059

```
MONTANA BUREAU OF MINES AND GEOLOGY          WATER QUALITY ANALYSIS
BUTTE,MONTANA  59701  (406)496 4101          LAB NO. 8002321

            STATE MONTANA                          COUNTY CASCADE
LATITUDE-LONGITUDE 47D23'59"N 111D10'10"W    SITE LOCATION 19N  3E 13 CABB
   UTM COORDINATES 12U N5249350 E387195          MBMG SITE AS 06
   TOPOGRAPHIC MAP SOUTHEAST GREAT FALLS 7.5    STATION ID 472359111101001
   GEOLOGIC SOURCE 221MRSN*111SPSN*          * SAMPLE SOURCE MINE DRAINAGE
    DRAINAGE BASIN BB                    LAND SURFACE ALTITUDE  3500.  FT   50
  AGENCY & SAMPLER MBMG*JJD                SUSTAINED YIELD
     BOTTLE NUMBER AS-06                  YIELD MEAS METHOD
      DATE SAMPLED 20 SEP-80             TOTAL DEPTH OF WELL
      TIME SAMPLED 16:00 HOURS    SWL ABOVE( ) OR BELOW GS
     LAB & ANALYST MBMG*ENA               CASING DIAMETER
     DATE ANALYZED 10-FEB-81                CASING TYPE
   SAMPLE HANDLING 4120                   COMPLETION TYPE    *
    METHOD SAMPLED GRAB                PERFORATION INTERVAL
         WATER USE UNUSED

    SAMPLING SITE SAND COULEE MINING DISTRICT*NO NAME CREEK
   GEOLOGIC SOURCE MORRISON FORMATION

                    MG/L      MEQ/L                              MG/L      MEQ/L
CALCIUM    (CA)      62.0       3.09 BICARBONATE    (HCO3)
MAGNESIUM  (MG)      88.8       7.31 CARBONATE      (CO3)
SODIUM     (NA)      18.2       0.79 CHLORIDE       (CL)          7.6       0.21
POTASSIUM   (K)       2.4       0.06 SULFATE        (SO4)      1060.       22.07
IRON       (FE)      74.1       3.98 NITRATE        (AS N)        .02       0.00
MANGANESE  (MN)       1.07      0.04 FLUORIDE       (F)           2.40      0.13
SILICA   (SIO2)      50.5            PHOSPHATE TOT (AS P)

  TOTAL CATIONS                15.27          TOTAL ANIONS                  22.41

  STANDARD DEVIATION OF ANION-CATION BALANCE   (SIGMA)

            LABORATORY PH      2.97    TOTAL HARDNESS AS CACO3    520.31
   FIELD WATER TEMPERATURE    10.4 C TOTAL ALKALINITY AS CACO3
CALCULATED DISSOLVED SOLIDS            SODIUM ADSORPTION RATIO      0.35
   SUM OF DISS. CONSTITUENT             RYZNAR STABILITY INDEX
LAB SPEC.COND.(MICROMHOS/CM)  1808.   LANGLIER SATURATION INDEX

      PARAMETER              VALUE          PARAMETER              VALUE
TEMPERATURE, AIR (C)        13.0 C    CNDUCTVY,FIELD M(CROMHOS     1701.
FIELD PH                     3.02     ALUMINUM, DISS (MG/L AL)     80.6
NICKEL,DISS (MG/L AS NI)      .42     SILVER,DISS (MG/L AS AG)      .002
LEAD,DISS  (MG/L AS PB)       .04     BORON ,DISS (MG/L AS B)       .17
STRONTIUM,DISS (MG/L-SR)      .36     CADMIUM,DISS(MG/L AS CD)      .010
TITANIUM DIS(MG/L AS TI)      .013    CHROMIUM, DISS (MG/L-CR)      .011
VANADIUM,DISS(MG/L AS V)      .027    COPPER,DISS (MG/L AS CU)      .009
ZINC,DISS  (MG/L AS ZN)       .82     LITHIUM,DISS(MG/L AS LI)      .35
ZIRCONIUM DIS(MG/L AS ZR     <.004    MOLYBDENUM,DISS(MG/L-MO)     <.02
ARSENIC,DISS(UG/L AS AS)     16.9     MERCURY,DISS(UG/L AS HG)      1.23
SELENIUM, DISS (UG/L-SE)      .3      ACIDITY,TOT(MG/L CACO3)     561.


REMARKS: SAMPLE CLEAR - NO PRECIPITATE *
         SPRING DISCHARGES FROM WITHIN SPOIL PILE IN FRONT OF ADIT *
         ADIT APPEARS DRY *
    LAB: NA=5.0 MG/L * 4.9 MEQVS/L, SIGMA .09, 22.5 TOTAL CATION MEQVS/L *


EXPLANATION:  MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L =
MILLIEQUIVELENTS PER LITER,  FT = FEET, MT = METERS,  (M) = MEASURED, (E) =
ESTIMATED, (R) = REPORTED,  TR = TOTAL RECOVERABLE,  TOT = TOTAL.

                        GW  WA  SS  WI  DW  PW  AT       OTHER
OTHER AVAILABLE DATA
OTHER FILE NUMBERS:

          PROJECT:                              COST:
   LAST EDIT DATE:  04 MAY 81                    BY:  TP *CLC
PROCESSING PROGRAM:  E1730P V2 (11/3/81)    PRINTED:  27 MAY 83

                  PERCENT MEQ/L (FOR PIPER PLOT)
                CA    MG    NA     K    CL   SO4 HCO3  CO3
              27.5  64.9   7.0   0.5   1.0 99.0   0.0   0.0

NOTE:  IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER:  8002321
```

```
MONTANA BUREAU OF MINES AND GEOLOGY              WATER QUALITY ANALYSIS
BUTTE,MONTANA  59701  (406)496-4101            LAB NO. 8002322

            STATE MONTANA                          COUNTY CASCADE
LATITUDE-LONGITUDE 47D23'48"N 111D10'20"W    SITE LOCATION 19N  4E 13 CBDC
   UTM COORDINATES Z12 N5242020 E436960          MBMG SITE AS-07
  TOPOGRAPHIC MAP SOUTHEAST GREAT FALLS 7 1/    STATION ID 472348111102001
  GEOLOGIC SOURCE 231MRSN*111SPBK*          *  SAMPLE SOURCE MINE DRAINAGE
    DRAINAGE BASIN BB                    LAND SURFACE ALTITUDE  3520.  FT < 50
 AGENCY + SAMPLER MBMG*JJD                  SUSTAINED YIELD
    BOTTLE NUMBER AS-07                    YIELD MEAS METHOD
      DATE SAMPLED 20-SEP-80             TOTAL DEPTH OF WELL
      TIME SAMPLED 17:00 HOURS     SWL ABOVE(-) OR BELOW GS
    LAB + ANALYST MBMG*ENA                  CASING DIAMETER
     DATE ANALYZED 18 FEB-81                   CASING TYPE
  SAMPLE HANDLING 9120                      COMPLETION TYPE    *
   METHOD SAMPLED GRAB                  PERFORATION INTERVAL
       WATER USE UNUSED

    SAMPLING SITE SAND COULEE MINING DISTRICT*NO-NAME CREEK
  GEOLOGIC SOURCE MORRISON FORMATION

                      MG/L      MEQ/L                                MG/L     MEQ/L
  CALCIUM    (CA)     188.       9.38 BICARBONATE    (HCO3)
  MAGNESIUM  (MG)     180.      14.81 CARBONATE       (CO3)
  SODIUM     (NA)      18.2      0.79 CHLORIDE        (CL)          4.1      0.12
  POTASSIUM  (K)        .6       0.02 SULFATE         (SO4)      7940.     165.31
  IRON       (FE)    1004.      53.93 NITRATE         (AS N)        .02      0.00
  MANGANESE  (MN)       4.45     0.16 FLUORIDE        (F)           7.2      0.38
  SILICA     (SIO2)   138.0           PHOSPHATE TOT (AS P)

    TOTAL CATIONS                79.09          TOTAL ANIONS                165.81

    STANDARD DEVIATION OF ANION CATION BALANCE   (SIGMA)

            LABORATORY PH      2.55     TOTAL HARDNESS AS CACO3   1210.32
    FIELD WATER TEMPERATURE    11.9 C TOTAL ALKALINITY AS CACO3
 CALCULATED DISSOLVED SOLIDS             SODIUM ABSORPTION RATIO      0.23
   SUM OF DISS. CONSTITUENT               RYZNAR STABILITY INDEX
LAB SPEC.COND.(MICROMHOS/CM)  6238.    LANGLIER SATURATION INDEX

      PARAMETER                VALUE          PARAMETER                VALUE
TEMPERATURE, AIR (C)          13.0 C    CNDUCTVY,FIELD MICROMHOS     6362.
FIELD PH                      2.38      ALUMINUM, DISS (MG/L-AL)     580.
NICKEL,DISS (MG/L AS NI)       3.58     SILVER,DISS (MG/L AS AG)        .007
LEAD,DISS  (MG/L AS PB)        <.04     BORON ,DISS (MG/L AS B)         .18
STRONTIUM,DISS (MG/L-SR)       1.16     CADMIUM,DISS(MG/L AS CD)        .034
TITANIUM DIS(MG/L AS TI)        .050    CHROMIUM, DISS (MG/L-CR)        .27
VANADIUM,DISS(MG/L AS V)        .25     COPPER,DISS (MG/L AS CU)        .37
ZINC,DISS  (MG/L AS ZN)       13.6      LITHIUM,DISS(MG/L AS LI)        .65
ZIRCONIUM DIS(MG/L AS ZR)       .069    MOLYBDENUM,DISS(MG/L-MO)        .02
ARSENIC,DISS(UG/L AS AS)      79.6      MERCURY,DISS(UG/L AS HG)        .04
SELENIUM, DISS (UG/L-SE)       2.1      ACIDITY,TOT(MG/L-CACO3)    5195.


REMARKS: CLEAR WATER - NO PRECIPITATE *
         SPRING RISES FROM WITHIN SPOIL PILE JUST SW OF MINE ADIT - SOUTH OF
         SAND COULEE * TRICKLE FROM ADIT DISCHARGE *
    LAB: NI=28.1 MG/L * 27.9 MEQVS/L * SIGMA 15.5, 128.8 TOTAL CATION MEQVS/L


EXPLANATION:  MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L =
MILLIEQUIVELENTS PER LITER.  FT = FEET, MT = METERS.  (M) = MEASURED, (E) =
ESTIMATED, (R) = REPORTED.  TR = TOTAL RECOVERABLE.  TOT = TOTAL.

                        GW  WA  SP  WI  OW  PW  AT       OTHER
OTHER AVAILABLE DATA
OTHER FILE NUMBERS:

          PROJECT:                              COST:
    LAST EDIT DATE:  04-MAY-81                    BY:  TP *CLC
PROCESSING PROGRAM:  F1730P V2 (11/3/81)     PRINTED:  27 MAY-83

                  PERCENT MEQ/L (FOR PIPER PLOT)
                CA    MG    NA    K    CL   SO4 HCO3  CO3
              37.5  59.2   3.2   0.1  0.1  99.9  0.0   0.0

NOTE:  IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER:  8002322
```

MONTANA BUREAU OF MINES AND GEOLOGY — WATER QUALITY ANALYSIS
BUTTE, MONTANA 59701 (406)496 4101 — LAB NO. 8002323

STATE	MONTANA	COUNTY	CASCADE
LATITUDE-LONGITUDE	47D18'42"N 111D11'09"W	SITE LOCATION	18N 3E 14 ACCC
UTM COORDINATES	212 N5239270 E405940	MBMG SITE NO	01
TOPOGRAPHIC MAP	SPRING COULEE 7 1/2'	STATION ID	121847111110201
GEOLOGIC SOURCE	221MRSN* *	SAMPLE SOURCE	MINE DRAINAGE
DRAINAGE BASIN	BB	LAND SURFACE ALTITUDE	3860. FT 10
AGENCY & SAMPLER	MBMG*JJD	SUSTAINED YIELD	
BOTTLE NUMBER	BS 01	YIELD MEAS METHOD	
DATE SAMPLED	20 SEP 80	TOTAL DEPTH OF WELL	
TIME SAMPLED	15:00 HOURS	SWL ABOVE(-) OR BELOW GS	
LAB & ANALYST	MBMG*SNA	CASING DIAMETER	
DATE ANALYZED	18-FEB-81	CASING TYPE	
SAMPLE HANDLING	1120	COMPLETION TYPE	*
METHOD SAMPLED	GRAB	PERFORATION INTERVAL	
WATER USE	UNUSED		

SAMPLING SITE SAND COULEE MINING DISTRICT*NO FIVE CREEK
GEOLOGIC SOURCE MORRISON FORMATION

	MG/L	MEQ/L		MG/L	MEQ/L
CALCIUM (CA)	121.	6.04	BICARBONATE (HCO3)		
MAGNESIUM (MG)	41.6	3.42	CARBONATE (CO3)		
SODIUM (NA)	14.9	0.65	CHLORIDE (CL)	3.5	0.10
POTASSIUM (K)	5.8	0.15	SULFATE (SO4)	546.	11.41
IRON (FE)	62.5	3.36	NITRATE (AS N)	.02	
MANGANESE (MN)	.39	0.01	FLUORIDE (F)	1.05	0.06
SILICA (SIO2)	20.6		PHOSPHATE TOT (AS P)		
TOTAL CATIONS		13.63	TOTAL ANIONS		11.56

STANDARD DEVIATION OF ANION CATION BALANCE (SIGMA)

LABORATORY PH	3.32	TOTAL HARDNESS AS CACO3	473.36
FIELD WATER TEMPERATURE	9.0 C	TOTAL ALKALINITY AS CACO3	
CALCULATED DISSOLVED SOLIDS		SODIUM ADSORPTION RATIO	0.30
SUM OF DISS. CONSTITUENT		RYZNAR STABILITY INDEX	
LAB SPEC.COND.(MICROMHOS/CM)	1209.	LANGLIER SATURATION INDEX	

PARAMETER	VALUE	PARAMETER	VALUE
TEMPERATURE, AIR (C)	16.0 C	CNDUCTVY,FIELD MICROMHOS	1122.
FIELD PH	5.41	ALUMINUM, DISS (MG/L-AL)	3.04
NICKEL,DISS (MG/L AS NI)	.30	SILVER,DISS (MG/L AS AG)	<.002
LEAD,DISS (MG/L AS PB)	<.04	BORON ,DISS (MG/L AS B)	.06
STRONTIUM,DISS (MG/L-SR)	.31	CADMIUM,DISS(MG/L AS CD)	.005
TITANIUM DIS(MG/L AS TI)	.018	CHROMIUM, DISS (MG/L-CR)	.004
VANADIUM,DISS(MG/L AS V)	.009	COPPER,DISS (MG/L AS CU)	.013
ZINC,DISS (MG/L AS ZN)	1.23	LITHIUM,DISS(MG/L AS LI)	.042
ZIRCONIUM DIS(MG/L AS ZR	<.004	MOLYBDENUM,DISS(MG/L MO)	<.02
ARSENIC,DISS(UG/L AS AS)	1.9	MERCURY,DISS(UG/L AS HG)	.04
SELENIUM, DISS (UG/L-SE)	.3	ACIDITY,TOT(MG/L-CACO3)	108.

REMARKS: WATER TURBID - SLIGHTLY MILKY * BECOMES PALE TO BRIGHT ORANGE UPON MIXING * GRIFFEN MINE OUTFLOW BS-01 * SAMPLE TAKEN FROM OUTFLOW FROM ADIT *
LAB: MH=0 MG/L, -2.9 SIGMA, 12.4 TOTAL CATION MEQVS/L *

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L = MILLIEQUIVELENTS PER LITER, FT = FEET, MT = METERS, (M) = MEASURED, (E) = ESTIMATED, (R) = REPORTED, TR = TOTAL RECOVERABLE, TOT - TOTAL.

	QW	WA	SD	NI	OW	PW	AT	OTHER
OTHER AVAILABLE DATA								
OTHER FILE NUMBERS:								

PROJECT: — COST:
LAST EDIT DATE: 04 MAY 81 — BY: TP *CLC
PROCESSING PROGRAM: F1730P V2 (11/3/81) — PRINTED: 27 MAY 83

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
58.9	33.4	6.3	1.5	0.9	99.1	0.0	0.0

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: 8002323

MONTANA BUREAU OF MINES AND GEOLOGY
BUTTE,MONTANA 59701 (406)496-4101

WATER QUALITY ANALYSIS
LAB NO. 81Q0060

STATE	MONTANA	COUNTY	CASCADE
LATITUDE-LONGITUDE	47D18'47"N 111D11'05"W	SITE LOCATION	18N 4E 14 ACCD
UTM COORDINATES	12 N5239780 E486090	MBMG SITE	BS-01
TOPOGRAPHIC MAP	STOCKETT 7 1/2'	STATION ID	471847111110501
GEOLOGIC SOURCE	221MRSN* *	* SAMPLE SOURCE	MINE DRAINAGE
DRAINAGE BASIN	BB	LAND SURFACE ALTITUDE	3840. FT < 10
AGENCY & SAMPLER	MBMG*JJD	SUSTAINED YIELD	
BOTTLE NUMBER	BS-01	YIELD MEAS METHOD	
DATE SAMPLED	03-MAR-81	TOTAL DEPTH OF WELL	
TIME SAMPLED	15:00 HOURS	SWL ABOVE(-) OR BELOW GS	
LAB & ANALYST	MBMG*ENA	CASING DIAMETER	
DATE ANALYZED	22-APR-81	CASING TYPE	
SAMPLE HANDLING	4120	COMPLETION TYPE	*
METHOD SAMPLED	GRAB	PERFORATION INTERVAL	
WATER USE	UNUSED		

SAMPLING SITE STOCKETT - SAND COULEE MINING DISTRICT
GEOLOGIC SOURCE MORRISON FORMATION

	MG/L	MEQ/L		MG/L	MEQ/L
CALCIUM (CA)	64.7	3.23	BICARBONATE (HCO3)		
MAGNESIUM (MG)	22.4	1.84	CARBONATE (CO3)		
SODIUM (NA)	7.7	0.33	CHLORIDE (CL)	4.8	0.14
POTASSIUM (K)	4.2	0.11	SULFATE (SO4)	632.	13.16
IRON (FE)	29.1	1.56	NITRATE (AS N)	.11	0.01
MANGANESE (MN)	.221	0.01	FLUORIDE (F)	1.23	0.06
SILICA (SIO2)	10.6		PHOSPHATE TOT (AS P)		
TOTAL CATIONS		7.09	TOTAL ANIONS		13.37

STANDARD DEVIATION OF ANION-CATION BALANCE (SIGMA)

LABORATORY PH	3.62	TOTAL HARDNESS AS CACO3	253.75
FIELD WATER TEMPERATURE	7.9 C	TOTAL ALKALINITY AS CACO3	
CALCULATED DISSOLVED SOLIDS		SODIUM ADSORPTION RATIO	0.21
SUM OF DISS. CONSTITUENT		RYZNAR STABILITY INDEX	
LAB SPEC.COND.(MICROMHOS/CM)	1984.	LANGLIER SATURATION INDEX	

PARAMETER	VALUE	PARAMETER	VALUE
TEMPERATURE, AIR (C)	10. C	CNDUCTVY,FIELD MICROMHOS	1038.
FIELD PH	5.39	ALKALINITY,FLD(AS CACO3)	60.4
ALUMINUM,TR (MG/L AS AL)	1.72	IRON,TR (MG/L AS FE)	30.2
ACIDITY,TOT(MG/L-CACO3)	408.8	ARSENIC,TR (UG/L AS AS)	5.2
SELENIUM,TR (UG/L AS SE)	<.1	ALUMINUM, DISS (MG/L-AL)	1.16
NICKEL,DISS (MG/L AS NI)	.24	SILVER,DISS (MG/L AS AG)	.057
LEAD,DISS (MG/L AS PB)	.05	BORON ,DISS (MG/L AS B)	.14
STRONTIUM,DISS (MG/L-SR)	.170	CADMIUM,DISS(MG/L AS CD)	.029
TITANIUM DIS(MG/L AS TI)	.012	CHROMIUM, DISS (MG/L-CR)	.040
VANADIUM,DISS(MG/L AS V)	.055	COPPER,DISS (MG/L AS CU)	.042
ZINC,DISS (MG/L AS ZN)	.600	LITHIUM,DISS(MG/L AS LI)	.069
ZIRCONIUM DIS(MG/L AS ZR	.074	MOLYBDENUM,DISS(MG/L-MO)	.27
ARSENIC,DISS(UG/L AS AS)	6.2	SELENIUM, DISS (UG/L-SE)	<.1

REMARKS: WATER SLIGHTLY TURBID - BUT LITTLE ORANGE FILTERATE *
CIFFEN MINE OUTFLOW - AT ADIT *
LAB: 13.7 CATION MEQVS. -.35 SIGMA, 12.2 MG/L EST. H4 *

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L = MILLIEQUIVALENTS PER LITER, FT = FEET, MT = METERS. (M) = MEASURED, (E) = ESTIMATED, (R) = REPORTED. TR = TOTAL RECOVERABLE. TOT = TOTAL.

	OW	WA	SS	WI	OW	PW	AT	OTHER
OTHER AVAILABLE DATA	Y							
OTHER FILE NUMBERS:								

PROJECT:		COST:	
LAST EDIT DATE:	29-APR-81	BY:	TP *CLC
PROCESSING PROGRAM:	F1730P V2 (11/3/81)	PRINTED:	27-MAY-83

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
58.5	33.4	6.1	2.0	1.0	99.0	0.0	0.0

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: 81Q0060

MONTANA BUREAU OF MINES AND GEOLOGY
BUTTE,MONTANA 59701 (406)496-4101

WATER QUALITY ANALYSIS
LAB NO. 8002324

STATE	MONTANA	COUNTY	CASCADE
LATITUDE-LONGITUDE	47D18'40"N 111D11'13"W	SITE LOCATION	18N 4E 14 CAAD
UTM COORDINATES	12 N5239640 E485850	MBMG SITE NO	02
TOPOGRAPHIC MAP	STOCKETT 7 1/2'	STATION ID	471840111113301
GEOLOGIC SOURCE	221MRSN* *	SAMPLE SOURCE	SPRING
DRAINAGE BASIN	BB	LAND SURFACE ALTITUDE	3860. FT (D
AGENCY + SAMPLER	MBMG*JJD	SUSTAINED YIELD	
BOTTLE NUMBER	BS-02	YIELD MEAS METHOD	
DATE SAMPLED	21-SEP-80	TOTAL DEPTH OF WELL	
TIME SAMPLED	13:00 HOURS	SWL ABOVE( ) OR BELOW OS	
LAB + ANALYST	MBMG*ENA	CASING DIAMETER	
DATE ANALYZED	05-DEC-80	CASING TYPE	
SAMPLE HANDLING	4120	COMPLETION TYPE	*
METHOD SAMPLED	GRAB	PERFORATION INTERVAL	
WATER USE	UNUSED		

SAMPLING SITE SAND COULEE MINING DISTRICT * NO. FIVE CR
GEOLOGIC SOURCE MORRISON FORMATION

		MG/L	MEQ/L			MG/L	MEQ/L
CALCIUM	(CA)	167.	8.33	BICARBONATE	(HCO3)	183.2	3.00
MAGNESIUM	(MG)	49.9	4.10	CARBONATE	(CO3)	0.	
SODIUM	(NA)	21.3	0.93	CHLORIDE	(CL)	6.1	0.17
POTASSIUM	(K)	5.68	0.15	SULFATE	(SO4)	490.	10.20
IRON	(FE)	34.8	1.87	NITRATE	(AS N)	.59	0.04
MANGANESE	(MN)	1.14	0.04	FLUORIDE	(F)	.87	0.05
SILICA	(SIO2)	8.2		PHOSPHATE TOT	(AS P)		
TOTAL CATIONS			15.42	TOTAL ANIONS			13.54

STANDARD DEVIATION OF ANION-CATION BALANCE (SIGMA) 5.94

LABORATORY PH	6.67	TOTAL HARDNESS AS CACO3	622.32
FIELD WATER TEMPERATURE	11.4 C	TOTAL ALKALINITY AS CACO3	154.11
CALCULATED DISSOLVED SOLIDS	878.14	SODIUM ADSORPTION RATIO	0.37
SUM OF DISS. CONSTITUENT	923.48	RYZNAR STABILITY INDEX	7.41
LAB SPEC.COND.(MICROMHOS/CM)	1144.	LANGLIER SATURATION INDEX	-0.37

PARAMETER	VALUE	PARAMETER	VALUE
TEMPERATURE, AIR (C)	10.0 C	CNDUCTVY,FIELD MICROMHOS	1124.
FIELD PH	8.59	ALUMINUM, DISS (MG/L-AL)	.23
STRONTIUM,DISS (MG/L-SR)	.37	SILVER,DISS (MG/L AS AG)	<.002
TITANIUM DIS(MG/L AS TI)	.023	BORON ,DISS (MG/L AS B)	.05
ZINC,DISS (MG/L AS ZN)	1.31	CADMIUM,DISS(MG/L AS CD)	.004
ZIRCONIUM DIS(MG/L AS ZR	<.004	CHROMIUM, DISS (MG/L-CR)	.002
SELENIUM, DISS (UG/L-SE)	.4	COPPER,DISS (MG/L AS CU)	.014
ARSENIC,DISS(UG/L AS AS)	<.1	LITHIUM,DISS(MG/L AS LI)	.044
MERCURY,DISS(UG/L AS HG)	<.03	MOLYBDENUM,DISS(MG/L-MO)	<.02
NICKEL,DISS (MG/L AS NI)	.34	LEAD,DISS (MG/L AS PB)	<.04
DISSLVD SOLIDS(CALC MG/L	878.		

REMARKS: WATER LOOKS PALE ORANGE * ORANGE AND WHITE PRECIPITATE IN FILTER *
R. SINGLES SPRING - GIFFEN MINE * SPRING EMITS OVER BROAD AREA NEAR
WHERE MINE ADIT WAS PLUGGED TO SHUTOFF ACID MINE DISCHARGE *
LAB: FU FE OF .017 MG/L GIVES -.035 SIGMA *

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L
MILLIEQUIVELENTS PER LITER. FT = FEET, MT = METERS. (M) = MEASURED, (E) =
ESTIMATED, (R) = REPORTED. TR = TOTAL RECOVERABLE. TOT = TOTAL.

OW WA SO WI OW PW AT OTHER

OTHER AVAILABLE DATA
OTHER FILE NUMBERS:

PROJECT:		COST:	
LAST EDIT DATE:	02-FEB-83	BY:	JKS*JKS
PROCESSING PROGRAM:	F1730P V2 (11/3/81)	PRINTED:	27-MAY-83

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
61.7	30.4	6.9	1.1	1.3	75.8	22.9	0.0

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: 8002324

MONTANA BUREAU OF MINES AND GEOLOGY
BUTTE, MONTANA 59701 (406)496-4101

WATER QUALITY ANALYSIS
LAB NO. B0G2325

STATE	MONTANA	COUNTY	CASCADE
LATITUDE-LONGITUDE	47D24'43"N 111D09'03"W	SITE LOCATION	19N 5E 7 CACB
UTM COORDINATES	ZI2 N5250740 E488590	MBMG SITE	CS-01
TOPOGRAPHIC MAP	SOUTHEAST GREAT FALLS 7 1	STATION ID	472443111090301
GEOLOGIC SOURCE	221MRSN* *	SAMPLE SOURCE	MINE DRAINAGE
DRAINAGE BASIN	BB	LAND SURFACE ALTITUDE	3490. FT < 10
AGENCY + SAMPLER	MBMG*JJD	SUSTAINED YIELD	
BOTTLE NUMBER	CS-01	YIELD MEAS METHOD	
DATE SAMPLED	21-SEP-80	TOTAL DEPTH OF WELL	
TIME SAMPLED	08:00 HOURS	SWL ABOVE(-) OR BELOW GS	
LAB + ANALYST	MBMG*ENA	CASING DIAMETER	
DATE ANALYZED	18-FEB-81	CASING TYPE	
SAMPLE HANDLING	4120	COMPLETION TYPE	*
METHOD SAMPLED	GRAB	PERFORATION INTERVAL	
WATER USE	UNUSED		

SAMPLING SITE SAND COULEE MINING DISTRICT*SAND COULEE CK
GEOLOGIC SOURCE MORRISON FORMATION

	MG/L	MEQ/L		MG/L	MEQ/L
CALCIUM (CA)	93.5	4.67	BICARBONATE (HCO3)		
MAGNESIUM (MG)	74.7	6.15	CARBONATE (CO3)		
SODIUM (NA)	22.3	0.97	CHLORIDE (CL)	6.3	0.18
POTASSIUM (K)	2.4	0.06	SULFATE (SO4)	980.	20.40
IRON (FE)	12.4	0.67	NITRATE (AS N)	.04	0.00
MANGANESE (MN)	.89	0.03	FLUORIDE (F)	3.4	0.18
SILICA (SIO2)	68.5		PHOSPHATE TOT (AS P)		
TOTAL CATIONS		12.54	TOTAL ANIONS		20.76

STANDARD DEVIATION OF ANION-CATION BALANCE (SIGMA)

LABORATORY PH	2.93	TOTAL HARDNESS AS CACO3	540.93
FIELD WATER TEMPERATURE	10.5 C	TOTAL ALKALINITY AS CACO3	
CALCULATED DISSOLVED SOLIDS		SODIUM ABSORPTION RATIO	0.42
SUM OF DISS. CONSTITUENT		RYZNAR STABILITY INDEX	
LAB SPEC.COND.(MICROMHOS/CM)	1839.	LANGLIER SATURATION INDEX	

PARAMETER	VALUE	PARAMETER	VALUE
TEMPERATURE, AIR (C)	10.0 C	CNDUCTVY,FIELD MICROMHOS	1862.
FIELD PH	2.80	ALUMINUM, DISS (MG/L-AL)	47.5
NICKEL,DISS (MG/L AS NI)	.54	SILVER,DISS (MG/L AS AG)	<.002
LEAD,DISS (MG/L AS PB)	<.04	BORON ,DISS (MG/L AS B)	.12
STRONTIUM,DISS (MG/L-SR)	.68	CADMIUM,DISS(MG/L AS CD)	.018
TITANIUM DIS(MG/L AS TI)	.016	CHROMIUM, DISS (MG/L-CR)	.005
VANADIUM,DISS(MG/L AS V)	.006	COPPER,DISS (MG/L AS CU)	.030
ZINC,DISS (MG/L AS ZN)	1.66	LITHIUM,DISS(MG/L AS LI)	.17
ZIRCONIUM DIS(MG/L AS ZR	<.004	MOLYBDENUM,DISS(MG/L-MO)	<.02
ARSENIC,DISS(UG/L AS AS)	1.7	MERCURY,DISS(UG/L AS HG)	<.03
SELENIUM, DISS (UG/L-SE)	.4	ACIDITY,TOT(MG/L-CACO3)	432.

REMARKS: CLEAR WATER - COLORLESS *
EFFLUENT FROM WOODEN DRAIN PIPE FROM ADIT - BURIED UNDER SPOIL *
LAB: PH=6.2 MG/L, .68 SIGMA, 20.5 TOTAL CATION MEQVS/L *

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L = MILLIEQUIVELENTS PER LITER. FT = FEET, MT = METERS. (M) = MEASURED, (E) = ESTIMATED, (R) = REPORTED. TR = TOTAL RECOVERABLE. TOT = TOTAL.

	GW	WA	SS	WI	OW	PW	AT	OTHER
OTHER AVAILABLE DATA								
OTHER FILE NUMBERS:								

PROJECT:		COST:	
LAST EDIT DATE:	04-MAY-81	BY:	TP *CLC
PROCESSING PROGRAM:	F1730P V2 (11/3/81)	PRINTED:	27-MAY-83

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
32.4	51.2	8.2	0.5	0.9	99.1	0.0	0.0

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: B0G2325

MONTANA BUREAU OF MINES AND GEOLOGY
BUTTE, MONTANA 59701 (406)496 4101

WATER QUALITY ANALYSIS
LAB NO. 8002327

STATE MONTANA
COUNTY CASCADE
LATITUDE-LONGITUDE 47D20'12"N 111D09'11"W
SITE LOCATION 10N 5E 6 CCAC
UTM COORDINATES 712 N5242350 E408510
MBMG SITE CS-09
TOPOGRAPHIC MAP STOCKETT 7 1/2'
STATION ID 472012111091101
GEOLOGIC SOURCE 221MRSN*111SPRK*
* SAMPLE SOURCE MINE DRAINAGE
DRAINAGE BASIN BB
LAND SURFACE ALTITUDE 3850. FT ± 10
AGENCY & SAMPLER MBMG*JJD
SUSTAINED YIELD
BOTTLE NUMBER CS-09
YIELD MEAS METHOD
DATE SAMPLED 21-SEP-80
TOTAL DEPTH OF WELL
TIME SAMPLED 15:00 HOURS
SWL ABOVE( ) OR BELOW CS
LAB & ANALYST MBMG*ENA
CASING DIAMETER
DATE ANALYZED 18-FEB-81
CASING TYPE
SAMPLE HANDLING 4120
COMPLETION TYPE *
METHOD SAMPLED GRAB
PERFORATION INTERVAL
WATER USE UNUSED

SAMPLING SITE SAND COULEE MINING DISTRICT*COTTONWOOD CK
GEOLOGIC SOURCE MORRISON FORMATION

		MG/L	MEQ/L			MG/L	MEQ/L
CALCIUM	(CA)	345.	17.22	BICARBONATE	(HCO3)		
MAGNESIUM	(MG)	149.	12.26	CARBONATE	(CO3)		
SODIUM	(NA)	14.7	0.64	CHLORIDE	(CL)	17.4	0.49
POTASSIUM	(K)	.8	0.02	SULFATE	(SO4)	6400.	134.91
IRON	(FE)	1057.	56.78	NITRATE	(AS N)	.03	0.00
MANGANESE	(MN)	2.46	0.09	FLUORIDE	(F)	.06	0.05
SILICA	(SIO2)	113.0		PHOSPHATE TOT	(AS P)		

TOTAL CATIONS 87.00 TOTAL ANIONS 135.45

STANDARD DEVIATION OF ANION-CATION BALANCE (SIGMA)

LABORATORY PH	2.90	TOTAL HARDNESS AS CACO3	1474.75
FIELD WATER TEMPERATURE	10.2 C	TOTAL ALKALINITY AS CACO3	
CALCULATED DISSOLVED SOLIDS		SODIUM ADSORPTION RATIO	0.17
SUM OF DISS. CONSTITUENT		RYZNAR STABILITY INDEX	
LAB SPEC.COND.(MICROMHOS/CM)	6287.	LANGLIER SATURATION INDEX	

PARAMETER	VALUE	PARAMETER	VALUE
TEMPERATURE, AIR (C)	9.0 C	CNDUCTVY,FIELD MICROMHOS	6747.
FIELD PH	2.45	ALUMINUM, DISS (MG/L AL)	479.
NICKEL,DISS (MG/L AS NI)	12.4	SILVER,DISS (MG/L AS AG)	.017
LEAD,DISS (MG/L AS PB)	<.04	BORON ,DISS (MG/L AS B)	.20
STRONTIUM,DISS (MG/L-SR)	1.06	CADMIUM,DISS(MG/L AS CD)	.15
TITANIUM DIS(MG/L AS TI)	.079	CHROMIUM, DISS (MG/L-CR)	.11
VANADIUM,DISS(MG/L AS V)	.21	COPPER,DISS (MG/L AS CU)	.12
ZINC,DISS (MG/L AS ZN)	62.9	LITHIUM,DISS(MG/L AS LI)	.70
ZIRCONIUM DIS(MG/L AS ZR	.090	MOLYBDENUM,DISS(MG/L-MO)	.05
ARSENIC,DISS(UG/L AS AS)	2.8	MERCURY,DISS(UG/L AS HG)	<.03
SELENIUM, DISS (UG/L-SE)	1.0	ACIDITY,TOT(MG/L-CACO3)	5295.

REMARKS: WATER DUMPING ORANGE AND RED PRECIPITATE * CLEAR AT SOURCE *
1.5 MILES SOUTH STOCKETT * SPRING EMITS FROM SPOIL PILE IN FRONT OF
CAVED ADIT * FLOW MEASURED AT ROAD - GREATER AT SOURCE *
LAB: NI=31 MG/L, -.22 SIGMA, 135.9 TOTAL CATION MEQVS/L *

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L = MILLIEQUIVELENTS PER LITER, FT = FEET, MI = METERS, (M) = MEASURED, (E) = ESTIMATED, (R) = REPORTED, TR = TOTAL RECOVERABLE, TOT = TOTAL.

OW WA SD WI OW PW AT OTHER

OTHER AVAILABLE DATA
OTHER FILE NUMBERS:

PROJECT:
COST:
LAST EDIT DATE: 04-MAY-81
BY: TP *CLC
PROCESSING PROGRAM: F1730P V2 (11/3/81)
PRINTED: 27-MAY 83

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
57.1	40.7	2.1	0.1	0.4	99.6	0.0	0.0

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: 8002327
Reads

MONTANA BUREAU OF MINES AND GEOLOGY
BUTTE,MONTANA 59701 (406)496-4101

WATER QUALITY ANALYSIS
LAB NO. 81G0061

STATE	MONTANA	COUNTY	CASCADE
LATITUDE-LONGITUDE	47D20'12"N 111D09'10"W	SITE LOCATION	18N 5E 6*CCAC
UTM COORDINATES	Z12 N5242395 E488515	MBMG SITE	CS-09
TOPOGRAPHIC MAP	STOCKETT 7 1/2'	STATION ID	472012111091001
GEOLOGIC SOURCE	221MRSN*111MTLG*	* SAMPLE SOURCE	MINE DRAINAGE
DRAINAGE BASIN	BB	LAND SURFACE ALTITUDE	3855. FT < 10
AGENCY + SAMPLER	MBMG*JJD	SUSTAINED YIELD	
BOTTLE NUMBER	CS-09	YIELD MEAS METHOD	
DATE SAMPLED	03-MAR-81	TOTAL DEPTH OF WELL	
TIME SAMPLED	14:00 HOURS	SWL ABOVE(-) OR BELOW GS	
LAB + ANALYST	MBMG*ENA	CASING DIAMETER	
DATE ANALYZED	22-APR-81	CASING TYPE	
SAMPLE HANDLING	1120	COMPLETION TYPE	*
METHOD SAMPLED	GRAB	PERFORATION INTERVAL	
WATER USE	UNUSED		

SAMPLING SITE STOCKETT - SAND COULEE MINING DISTRICT
GEOLOGIC SOURCE MORRISON FORMATION

	MG/L	MEQ/L		MG/L	MEQ/L
CALCIUM (CA)	360.	17.96	BICARBONATE (HCO3)		
MAGNESIUM (MG)	155.	12.75	CARBONATE (CO3)		
SODIUM (NA)	14.1	0.61	CHLORIDE (CL)	1.9	0.05
POTASSIUM (K)	2.6	0.07	SULFATE (SO4)	6906.	143.78
IRON (FE)	1065.	57.21	NITRATE (AS N)	.18	0.01
MANGANESE (MN)	2.56	0.09	FLUORIDE (F)	7.46	0.39
SILICA (SIO2)	106.0		PHOSPHATE TOT (AS P)		
TOTAL CATIONS		88.70	TOTAL ANIONS		144.24

STANDARD DEVIATION OF ANION-CATION BALANCE (SIGMA)

LABORATORY PH	2.82	TOTAL HARDNESS AS CACO3	1536.90
FIELD WATER TEMPERATURE	8.6 C	TOTAL ALKALINITY AS CACO3	
CALCULATED DISSOLVED SOLIDS		SODIUM ADSORPTION RATIO	0.16
SUM OF DISS. CONSTITUENT		RYZNAR STABILITY INDEX	
LAB SPEC.COND.(MICROMHOS/CM)	6251.	LANGLIER SATURATION INDEX	

PARAMETER	VALUE	PARAMETER	VALUE
TEMPERATURE, AIR (C)	10. C	CNDUCTVY,FIELD MICROMHOS	6826.
FIELD PH	2.53	ALUMINUM,TR (MG/L AS AL)	1220.
IRON,TR (MG/L AS FE)	1290.	ACIDITY,TOT(MG/L-CACO3)	5431.
ARSENIC,TR (UG/L AS AS)	6.0	SELENIUM,TR (UG/L AS SE)	.8
ALUMINUM, DISS (MG/L-AL)	500.	NICKEL,DISS (MG/L AS NI)	12.8
SILVER,DISS (MG/L AS AG)	.022	LEAD,DISS (MG/L AS PB)	<.04
BORON ,DISS (MG/L AS B)	.33	STRONTIUM,DISS (MG/L-SR)	.103
CADMIUM,DISS(MG/L AS CD)	.112	TITANIUM DIS(MG/L AS TI)	.014
CHROMIUM, DISS (MG/L-CR)	.144	VANADIUM,DISS(MG/L AS V)	.033
COPPER,DISS (MG/L AS CU)	.154	ZINC,DISS (MG/L AS ZN)	4.85
LITHIUM,DISS(MG/L AS LI)	.728	ZIRCONIUM DIS(MG/L AS ZR	.025
MOLYBDENUM,DISS(MG/L-MO)	1.42	ARSENIC,DISS(UG/L AS AS)	6.0
SELENIUM, DISS (UG/L-SE)	.6		

REMARKS: SAMPLE CLEAR - NO PRECIPITATE * DOWNSTREAM THERE IS ORANGE AND WHITE
PRECIPITATE AND GREEN SLIME * SAMPLE FROM SPRING AT SPOIL PILE BY TH
MINE * AT ROAD, PH=2.72, S.C.=6725 *

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L
MILLIEQUIVELENTS PER LITER. FT = FEET, MT = METERS. (M) = MEASURED, (E) =
ESTIMATED, (R) = REPORTED. TR = TOTAL RECOVERABLE. TOT = TOTAL.

	GW	WA	SS	WI	OW	PW	AT	OTHER
OTHER AVAILABLE DATA	Y							

OTHER FILE NUMBERS:

PROJECT:		COST:	
LAST EDIT DATE:	19-FEB-82	BY:	TP *JKS
PROCESSING PROGRAM:	F1730P V2 (11/3/81)	PRINTED:	27-MAY-83

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
57.2	40.6	2.0	0.2	0.0	100.0	0.0	0.0

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: 81G0061
ANALYSIS NOT IN FILE: 81G1000

```
MONTANA BUREAU OF MINES AND GEOLOGY          WATER QUALITY ANALYSIS
BUTTE,MONTANA  59701  (406)496 4101         LAB NO. S0G2326

              STATE MONTANA                        COUNTY CASCADE
 LATITUDE-LONGITUDE 47D23'21"N 111D07'59"W    SITE LOCATION 19N  5E 20 BBDC
    UTM COORDINATES 12 N5248170 E382950          MBMG SITE DS-01
    TOPOGRAPHIC MAP SOUTHEAST GREAT FALLS 7 1    STATION ID 472321111075901
    GEOLOGIC SOURCE 221MRSN*111SSRK*          * SAMPLE SOURCE MINE DRAINAGE
     DRAINAGE BASIN BB                  LAND SURFACE ALTITUDE  3590.  FT   50
  AGENCY & SAMPLER MBMG*JJD                SUSTAINED YIELD
     BOTTLE NUMBER CS-05                   YIELD MEAS METHOD
       DATE SAMPLED 21-SEP-80              TOTAL DEPTH OF WELL
       TIME SAMPLED 10:00 HOURS     SWL ABOVE(-) OR BELOW GS
     LAB & ANALYST MBMG*ENA                CASING DIAMETER
       DATE ANALYZED 18-FEB-81             CASING TYPE
    SAMPLE HANDLING 4120                   COMPLETION TYPE    *
     METHOD SAMPLED GRAB                 PERFORATION INTERVAL
          WATER USE UNUSED

     SAMPLING SITE SAND COULEE MINING DISTRICT*SAND COULEE CR
   GEOLOGIC SOURCE MORRISON FORMATION

                      MG/L      MEQ/L                              MG/L     MEQ/L
  CALCIUM    (CA)     181.       9.03 BICARBONATE    (HCO3)
  MAGNESIUM  (MG)      62.6      5.15 CARBONATE      (CO3)
  SODIUM     (NA)      13.6      0.59 CHLORIDE       (CL)          5.2      0.15
  POTASSIUM  (K)        2.4      0.06 SULFATE        (SO4)      1437.      29.92
  IRON       (FE)      31.3      1.68 NITRATE        (AS N)       .04      0.00
  MANGANESE  (MN)       .70      0.03 FLUORIDE       (F)         3.54      0.19
  SILICA     (SIO2)    98.2           PHOSPHATE TOT  (AS P)

    TOTAL CATIONS               16.54          TOTAL ANIONS                30.25

    STANDARD DEVIATION OF ANION-CATION BALANCE    (SIGMA)

             LABORATORY PH      2.31     TOTAL HARDNESS AS CACO3    709.62
     FIELD WATER TEMPERATURE   11.2 C  TOTAL ALKALINITY AS CACO3
  CALCULATED DISSOLVED SOLIDS          SODIUM ADSORPTION RATIO       0.22
    SUM OF DISS. CONSTITUENT           RYZNAR STABILITY INDEX
 LAB SPEC.COND.(MICROMHOS/CM)  2922.   LANGLIER SATURATION INDEX

      PARAMETER              VALUE          PARAMETER              VALUE
TEMPERATURE, AIR (C)          8.   C  CNDUCTVY,FIELD MICROMHOS    3027.
FIELD PH                     2.50    ALUMINUM, DISS (MG/L-AL)     66.6
NICKEL,DISS (MG/L AS NI)      .36    SILVER,DISS (MG/L AS AG)      .006
LEAD,DISS  (MG/L AS PB)      <.04    BORON ,DISS (MG/L AS B)       .10
STRONTIUM,DISS (MG/L-SR)      .73    CADMIUM,DISS(MG/L AS CD)      .016
TITANIUM DIS(MG/L AS TI)      .033   CHROMIUM, DISS (MG/L-CR)      .013
VANADIUM,DISS(MG/L AS V)      .016   COPPER,DISS (MG/L AS CU)      .035
ZINC,DISS  (MG/L AS ZN)      1.04    LITHIUM,DISS(MG/L AS LI)      .12
ZIRCONIUM DIS(MG/L AS ZR      .005   MOLYBDENUM,DISS(MG/L-MO)     <.02
ARSENIC,DISS(UG/L AS AS)     <.1     MERCURY,DISS(UG/L AS HG)     <.03
SELENIUM, DISS (UG/L-SE)      .4     ACIDITY,TOT(MG/L-CACO3)     722.


REMARKS: WATER IS MURKY - FILTERS POORLY DUE TO SEDIMENT *  WATER SEEPS OVER
         BROAD AREA OF MINE SPOIL * SOME MIXING WITH HIGHER PH * NATURAL SPRING
         DISCHARGE (PH FROM 3-5) * OUTFLOW AT ROAD AT 1600M, PH=2.70 * WATER
    LAB: SEEPS RAPIDLY BACK INTO GROUND ALONG DRAINAGE CHANNEL *
    LAB: NA=11.3 MG/L, -.01 SIGMA, 30.3 TOTAL CATION MEQVS/L *

EXPLANATION:  MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L =
MILLIEQUIVELENTS PER LITER.  FT = FEET, MT = METERS.  (M) = MEASURED, (E) =
ESTIMATED, (R) = REPORTED.  TR = TOTAL RECOVERABLE.  TOT = TOTAL.

                         GW  WA  SS  WI  GW  SW  AT       OTHER
OTHER AVAILABLE DATA
OTHER FILE NUMBERS:

          PROJECT:                              COST:
    LAST EDIT DATE:  04-MAY-81                   BY:   TP *CLC
PROCESSING PROGRAM:  F1730P V2 (11/3/81)    PRINTED:   27 MAY 83

                  PERCENT MEQ/L (FOR PIPER PLOT)
                    CA    MG    NA     K    CL   SO4  HCO3   CO3
                  60.9  34.7   4.0   0.4   0.5  99.5   0.0   0.0

NOTE:  IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER:  S0G2326
```

APPENDIX B

GEOLOGY

A comprehensive description of the Mesozoic stratigraphy of the area is presented in Silverman and Harris (1967), and comments regarding the geology of the area are largely derived from their report and from field inspection.

B.1 Madison Group (Mississippian)

The Madison Group is the oldest geologic unit exposed in the area. Its top is exposed in several localities along the bottoms of Cottonwood, Number Five and Sand Coulees. Outcrops are not extensive; the largest observed exposure is about thirty feet thick. Feltis (1980, 3) shows the top of the Madison in this area to dip to the north-northwest at a relatively uniform dip of 50-70 feet/mile (about one degree). However, exposures in this area suggest that the top of the formation may be irregular, projecting local domes or knobs. It is probably located at shallow (<300 feet) depth in the subsurface throughout the study.

The Madison is overlain unconformably by Jurassic sediments of the Ellis Group. This unconformity is angular, as exposed 0.5 km north of Stockett, where folded Madison strata dip 25 degrees north-northeast beneath flay-lying sandstone of the Ellis. The Madison may exhibit more complex structure in the subsurface than the gently-dipping Cretaceous and Jurassic sediments which overlie it.

The lithology of the Madison is grey, coarsely-crystalline limestone and dolomitic limestone, with chert grains and a diverse

biohermal fossil assemblage. It occurs both in thin, flaggy beds and in massive biohermal strata. Some fossil casts have been refilled with either calcite or gypsum. Local residents report that the limestone is locally cavernous along Sand Coulee Creek farther south towards the mountains. Water well drillers have reported encountering cavernous zones in the upper Madison in the Stockett and Sand Coulee area.

B.2 Swift Formation and Ellis Group (Jurassic)

Sandstone of the Swift Formation, the upper member of the Ellis Group, is distinctive in outcrop as a cemented, cross-bedded, grey, massive- to flaggy-bedded sandstone. Outcrops are found along coulee bottoms in the upper reaches of the Sand Coulee Creek drainage, particularly south of Stockett. In some localities, it unconformably overlies the Madison, but it usually overlies yellow and grey shales and mudstones of the lower Ellis Group. The fine-grained sediments of the Ellis are poorly resistant to erosion and are not well exposed in the area.

B.3 Morrison Formation (Jurassic)

The Morrison Formation consists of 50-250 feet of grey mudstone, with interbedded lenses of limestone, sandstone, coal and shale. Coal mined in the Sand Coulee area is from bed(s) at or near the top of the Morrison. The uppermost coal bed is directly overlain by a cemented conglomeratic channel sandstone at the base of the Kootenai Formation (Cretaceous).

Although the upper coal seam was the primary target of mining in this area, at least one other minable seam may occur in the subsurface

of the area. In the Giffin mine workings, local residents report that mining took place at two separate levels separated by approximately 30 feet of interburden material.

Morrison outcrops are found in this area along the mid-slopes of the coulees. The upper part of the Morrison consists of coal, carbonaceous shale and fine-grained sandstone lenses, up to a total thickness of sixty feet. The coal bed ranges from 1-12 feet thick, with varying proportions of interbedded carbonaceous shale. The thickness of these shale strata was one of the controls on the profitability of mining.

Sandstone lenses in the Morrison are up to 35 feet thick. They are clean fluvial deposits and weather orange, making them difficult to distinguish from some of the sandstones in the overlying Kootenai. Perhaps the most diagnostic characteristic of the Morrison is its varied assemblage of interbedded lithologies, including shale, mudstone, coal, sandstone and fresh water limestone.

B.4 Kootenai Formation (Lower Cretaceous)

The Kootenai Formation is a sequence of numerous lensaic, discontinuous sandstone beds from one to 50 feet thick, interbedded with green and grey mudstone. It forms the coulee walls and underlies the upland benches between coulees throughout the study area. The basal sandstone unit of the Kootenai, the Third Cat Creek equivalent in this area, overlies the coal in the Upper Morrison with an erosional unconformity. This unit represents the first coarse channel deposits of the major river system which established itself across the Upper Jurassic land surface.

Except for the basal sandstone, the numerous sandstone beds in the

upper Kootenai are relatively discontinuous. Most individual beds cannot be traced over long distances.

B.5 Glacial Deposits

According to Coulton et al. (1961), the limit of Wisconsinan continental glaciation lies just to the north of the Sand Coulee area. No known till or drift deposits occur within the valley. There is a large pre-glacial channel of the Missouri River which runs east-west from the modern Missouri River south of Great Falls, at the Sand Coulee Creek delta, directly west to the town of Fife. The flow of Sand Coulee Creek turns abruptly to the west as it encounters this channel. The channel is filled with sand, gravel, silt and clay deposited by glaciers and glacial lakes over which the lower reach of Sand Coulee Creek flows at a gentle gradient of 9-10 feet/mile (about 2%).

B.6 Alluvial Deposits

Thin alluvial deposits of Quaternary and possibly Tertiary age lie along the coulee bottoms of Straight, Cottonwood, Number Five and Sand Coulee Creeks. North of Tracy, these alluvial deposits inter-finger with the outwash and lacusterine deposits of the ancient Missouri channel. Thickness of the alluvial cover is variable. Although little data on its thickness distribution are available, it is probable that nowhere south of Tracy is it greater than 100 feet.

APPENDIX C

HYDROGEOLOGICAL DATA

C-1

DOMESTIC WELL INVENTORY FIELD SHEETS

MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY CASCADE T. 17 (N) or S R. 4 (E) or W SEC. 2 TRACT BDDA

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN SUBDIVISION BLOCK LOT

OWNER'S NAME DONALD JACOBS ADDRESS

PHONE NUMBER YEAR

ALT. LAND SURF. AT WELL MSL 4303 ft.
TOTAL DEPTH BELOW LSD 90 ft.
PUMPING LEVEL BELOW LSD ft.
STATIC WATER LEVEL* BELOW LSD ft.
YIELD IN GALLONS PER MIN.
HOW TESTED TIME (HR.)
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O

CASING DIA. in. FROM ft. TO ft.
in. FROM ft. TO ft.
CASING TYPE
PERFORATED INTERVAL ft. TO ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC.
PUMP SIZE (HP.) TYPE
DATE WELL COMPLETED
HOW DRILLED
BY WHOM LIC.
WELL USE
SOURCE OF INFO: WELL APPROP.
DRILLER OWNER USGS SCS
OTHER:

HAS WELL LOCATION BEEN VERIFIED Yes
BY WHOM T. Osborne AGENCY MBMG
DATE VERIFIED 8-19-82
MEAS. POINT ABOVE LSD ft. DATE
TOTAL DEPTH BELOW LSD ft.
PUMPING LEVEL BELOW LSD ft.
SWL* BELOW LSD 74.88 ft. 8-19-82
YIELD IN GPM
WATER TEMP. °C
SPECIFIC COND. at 25°C
MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER:

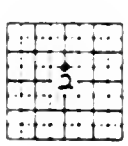
REMARKS:

*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG		
INTERVAL (FT.)		
FROM	TO	DESCRIPTION
		No LOG

SKETCH MAP



Well at white shed 200 yards South of House

To stock tank

House

Well

N

C-1

MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY CASCADE T. 17 (N) or S R. 5 (E) or W SEC. 7 TRACT CBA

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN SUBDIVISION BLOCK LOT

OWNER'S NAME SCHOTT ADDRESS

PHONE NUMBER YEAR

ALT. LAND SURF. AT WELL MSL 4210 ft.
TOTAL DEPTH BELOW LSD 125 ft.
PUMPING LEVEL BELOW LSD ft.
STATIC WATER LEVEL* BELOW LSD ft.
YIELD IN GALLONS PER MIN.
HOW TESTED TIME (HR.)
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O

CASING DIA. in. FROM ft. TO ft.
in. FROM ft. TO ft.
CASING TYPE
PERFORATED INTERVAL ft. TO ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC.
PUMP SIZE (HP.) TYPE
DATE WELL COMPLETED
HOW DRILLED
BY WHOM LIC.
WELL USE
SOURCE OF INFO: WELL APPROP.
DRILLER OWNER USGS SCS
OTHER:

HAS WELL LOCATION BEEN VERIFIED Yes
BY WHOM T Osborne AGENCY MBMG
DATE VERIFIED 8-19-82
MEAS. POINT ABOVE LSD 3.19 ft. DATE
TOTAL DEPTH BELOW LSD 126.5 ft.
PUMPING LEVEL BELOW LSD ft.
SWL* BELOW LSD 108.86 ft. 8-19-82
YIELD IN GPM
WATER TEMP. °C
SPECIFIC COND. at 25°C 355 8-19-82
MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER:

REMARKS:
397 @ 30.1°C

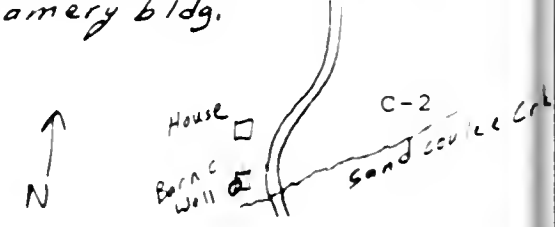
*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG		
INTERVAL (FT.)		DESCRIPTION
FROM	TO	

SKETCH MAP

West side of road just off of Sand Coulee Crk. Bridge at creamery bldg.



K2

MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY CASCADE T. 18 N or S R. 4 E or W SEC. 11 TRACT AAAS

LAT. ° ' " N. LONG. ° ' " W. UTM ____ N ____ E ____

TOWN ____ SUBDIVISION ____ BLOCK ____ LOT ____

OWNER'S NAME DONALD A. YUREK ADDRESS STOCKETT MT. 59480

PHONE NUMBER ____ YEAR ____

ALT. LAND SURF. AT WELL MSL 4075 ft.
TOTAL DEPTH BELOW LSD 131 ft.
PUMPING LEVEL BELOW LSD 125 ft.
STATIC WATER LEVEL* BELOW LSD 26 ft.
YIELD IN GALLONS PER MIN. 2
HOW TESTED BAILER TIME (HR.) 2
IF F, SHUT-IN PRESS. IN PSI ____
GEOLOGICAL SOURCE OF H_2O SANDY SHALE KOOTENAI & MADISON

CASING DIA. 6 5/8 in. FROM 0 ft. TO 65 ft.
____ in. FROM ____ ft. TO ____ ft.
CASING TYPE STEEL
PERFORATED INTERVAL 31' ft. TO ____ ft.
61' ft. TO ____ ft.
____ ft. TO ____ ft.
PERFORATION DESC. .25" SLOTS
PUMP SIZE (HP.) ____ TYPE ____
DATE WELL COMPLETED 2/11/1981
HOW DRILLED CABLE
BY WHOM PAT BYRNE LIC. 318
WELL USE STOCK & DOMESTIC
SOURCE OF INFO: WELL APPROP. ✓
DRILLER ___ OWNER ___ USGS ___ SCS ___
OTHER: ____

HAS WELL LOCATION BEEN VERIFIED Yes
BY WHOM HERMAN MOORE AGENCY MBMG
DATE VERIFIED 6/21/82

			DATE
MEAS. POINT ABOVE LSD	____	ft.	
TOTAL DEPTH BELOW LSD	____	ft.	
PUMPING LEVEL BELOW LSD	____	ft.	
SWL* BELOW LSD	7.70	ft.	6/21/82
YIELD IN GPM	7.2		6/21/82
WATER TEMP. °C	12.1		6/21/82
SPECIFIC COND. at 25°C	677		6/21/82

MBMG FILE NUMBER ____
DNR FILE NUMBER ____
WELL FORM NUMBER ____
MBMG WQ LAB. NUMBER ____
SYS 2000 NUMBER ____
OTHER: ____

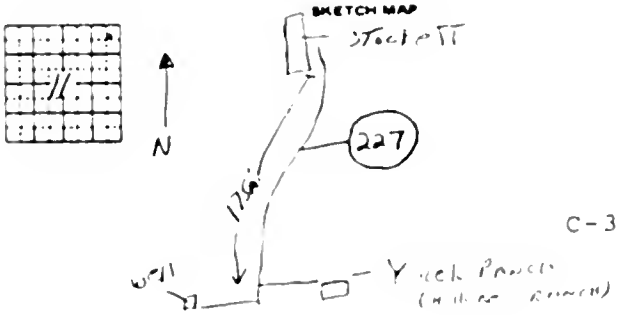
REMARKS: ____

*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	4	TOP SOIL
4	30	BROKEN SANDSTONE, CLAY AND SANDSTONE BOULDERS
30	38	DARK BROWN-GREY SHALE
38	41	HARD-GRAY LIMY SHALE
41	43	LIGHT GRAY SHALE
43	48	MAROON SHALE
48	49	RED ROCK
49	58	RED ROCK AND SHALE
58	76	VERIGATED LIMEY SANDROCK 2 GPM 65-70
76	81	MAROON SHALE ROCK
81	84	HARD RED LIMEY SANDROCK
84	90	VERIGATED SHALE ROCK
90	96	VERIGATED SHALE
96	102	VERIGATED SAND ROCK
102	105	RED ROCK
105	120	GRAY-GREEN SANDY SHALE ROCK
120	126	SHARP GRAY SANDSTONE
126	129	COAL
129	131	DARK GRAY SANDY SHALE
TD	PK	7.27.19



C-3

SPRING

MONTANA BUREAU OF MINES AND GEOLOGY
WELL DATA SHEET

COUNTY CASCADE T. 18 (N) or S R. 4 (E) or W SEC. 14 TRACT ACBD
SPRING

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN SUBDIVISION BLOCK LOT

OWNER'S NAME Rick Yurek ADDRESS EVANS RT. STOCKETT

PHONE NUMBER YEAR

ALT. LAND SURF. AT WELL MSL 3880 ft.
TOTAL DEPTH BELOW LSD ft.
PUMPING LEVEL BELOW LSD ft.
STATIC WATER LEVEL* BELOW LSD ft.
YIELD IN GALLONS PER MIN.
HOW TESTED TIME (HR.)
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O KOOTENAI

CASING DIA. in. FROM ft. TO ft.
in. FROM ft. TO ft.
CASING TYPE
PERFORATED INTERVAL ft. TO ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC.
PUMP SIZE (HP.) TYPE
DATE WELL COMPLETED
HOW DRILLED
BY WHOM LIC.
WELL USE
SOURCE OF INFO: WELL APPROP.
DRILLER OWNER USGS SCS
OTHER:

SPRING
HAS WELL LOCATION BEEN VERIFIED Yes
BY WHOM HERMAN MOORE AGENCY MBMG
DATE VERIFIED 6/09/82

MEAS. POINT ABOVE LSD		ft.	DATE
TOTAL DEPTH BELOW LSD		ft.	
PUMPING LEVEL BELOW LSD		ft.	
SWL* BELOW LSD		ft.	
YIELD IN GPM	9		6/21/82
WATER TEMP. °C	10.5		6/09/82
SPECIFIC COND. at 25°C	542		6/21/82

MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER:

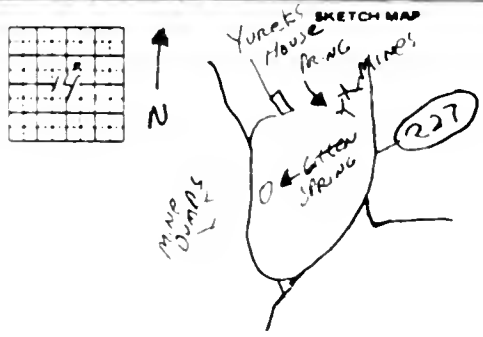
REMARKS: DRILLED TWO WELLS BOTH HIT COAL AND WENT DRY. WELL WAS HOOK UP TO FAMILIES WELL. AT 18N-4E-11-AAAC

*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION



C-4

MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY CASCADE T. 18 (N) S R. 4 (E) W SEC. 23 TRACT ABBB

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN SUBDIVISION BLOCK LOT

OWNER'S NAME RALPH SINGLE ADDRESS STAR RT. STOCKETT

PHONE NUMBER YEAR

ALT. LAND SURF. AT WELL MSL 3910 ft.
TOTAL DEPTH BELOW LSD 55 ft.
PUMPING LEVEL BELOW LSD ft.
STATIC WATER LEVEL* BELOW LSD 25 ft.
YIELD IN GALLONS PER MIN.
HOW TESTED TIME (HR.)
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O SAND STONE IND. SR

CASING DIA. 6 in. FROM 0 ft. TO 25 ft.
in. FROM ft. TO ft.
CASING TYPE PLASTIC
PERFORATED INTERVAL ft. TO ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC.
PUMP SIZE (HP.) TYPE
DATE WELL COMPLETED
HOW DRILLED
BY WHOM LIC.
WELL USE DOMESTIC & STOCK
SOURCE OF INFO: WELL APPROP.
DRILLER OWNER X USGS SCS
OTHER:

HAS WELL LOCATION BEEN VERIFIED YES
BY WHOM HERMAN R. BOOS AGENCY MBMG
DATE VERIFIED 6/04/82
MEAS. POINT ABOVE LSD ft. DATE
TOTAL DEPTH BELOW LSD ft.
PUMPING LEVEL BELOW LSD ft.
SWL* BELOW LSD ft.
YIELD IN GPM 3 6/21/82
WATER TEMP. °C 9.2° 6/04/82
SPECIFIC COND. at 25°C 528 6/21/82
MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER:

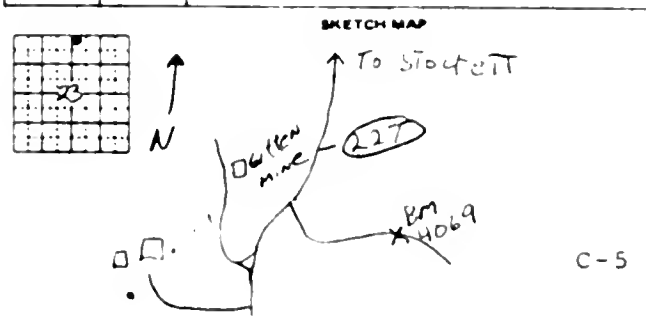
REMARKS:

*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG		
INTERVAL (FT.)		DESCRIPTION
FROM	TO	

SKETCH MAP



C-5

MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY CASCADE T. 18 (N)or S R. 4 (E)or W SEC. 28 TRACT CADA

LAT. ° ' " N. LONG. ° ' " W. UTM ____ N ____ E ____

TOWN ____ SUBDIVISION ____ BLOCK ____ LOT ____

OWNER'S NAME Eugene Vice ADDRESS EDEN RT. Stockett

PHONE NUMBER ____ YEAR ____

ALT. LAND SURF. AT WELL MSL 4340 ft.
TOTAL DEPTH BELOW LSD 90' ft.
PUMPING LEVEL BELOW LSD ____ ft.
STATIC WATER LEVEL* BELOW LSD 39' ft.
YIELD IN GALLONS PER MIN. ____
HOW TESTED ____ TIME (HR.) ____
IF F, SHUT-IN PRESS. IN PSI ____
GEOLOGICAL SOURCE OF H_2O SANDSTONE KOOTENAI

CASING DIA. 6 in. FROM ____ ft. TO ____ ft.
____ in. FROM ____ ft. TO ____ ft.
CASING TYPE Steel
PERFORATED INTERVAL ____ ft. TO ____ ft.
____ ft. TO ____ ft.
____ ft. TO ____ ft.
PERFORATION DESC. ____
PUMP SIZE (HP.) ____ TYPE ____
DATE WELL COMPLETED ____
HOW DRILLED ____
BY WHOM FRANKLIN LIC. ____
WELL USE Domestic & Stock
SOURCE OF INFO: WELL APPROP. ____
DRILLER ____ OWNER X USGS ____ SCS ____
OTHER: ____

HAS WELL LOCATION BEEN VERIFIED Yes
BY WHOM Herman Moore AGENCY M.B.M.G.
DATE VERIFIED 6/07/82

		DATE
MEAS. POINT ABOVE LSD	____ ft.	
TOTAL DEPTH BELOW LSD	____ ft.	____
PUMPING LEVEL BELOW LSD	____ ft.	____
SWL* BELOW LSD	____ ft.	____
YIELD IN GPM	____	____
WATER TEMP. °C	13.3°	6/07/82
SPECIFIC COND. at 25°C	1041	6/07/82

MBMG FILE NUMBER ____
DNR FILE NUMBER ____
WELL FORM NUMBER ____
MBMG WQ LAB. NUMBER ____
SYS 2000 NUMBER ____
OTHER: ____

REMARKS: ____

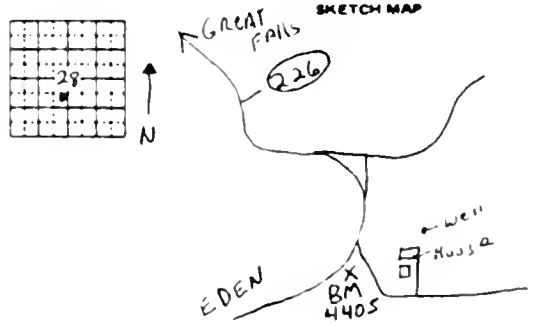
*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION

SKETCH MAP



MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY CASCADE T. 15 (N) or S R. 5 (E) or W SEC. 6 TRACT BBDB

LAT. ° ' " N. LONG. ° ' " W. UTM ____ N ____ E ____

TOWN ____ SUBDIVISION ____ BLOCK ____ LOT ____

OWNER'S NAME MATT FRISNEGGER ADDRESS STOCKETT

____ PHONE NUMBER ____ YEAR ____

ALT. LAND SURF. AT WELL MSL 3695 ft.
TOTAL DEPTH BELOW LSD 58' ft.
PUMPING LEVEL BELOW LSD UNUSED ft.
STATIC WATER LEVEL* BELOW LSD 29.48 ft.
YIELD IN GALLONS PER MIN. ____
HOW TESTED ____ TIME (HR.) ____
IF F, SHUT-IN PRESS. IN PSI ____
GEOLOGICAL SOURCE OF H_2O SANDSTONE MORRISON

CASING DIA. 6 in. FROM ____ ft. TO ____ ft.
____ in. FROM ____ ft. TO ____ ft.
CASING TYPE Steel
PERFORATED INTERVAL ____ ft. TO ____ ft.
____ ft. TO ____ ft.
____ ft. TO ____ ft.
PERFORATION DESC. ____
PUMP SIZE (HP.) ____ TYPE ____
DATE WELL COMPLETED ____
HOW DRILLED ____
BY WHOM ____ LIC. ____
WELL USE UNUSED
SOURCE OF INFO: WELL APPROP. ____
DRILLER ____ OWNER X USGS ____ SCS ____
OTHER: ____

HAS WELL LOCATION BEEN VERIFIED Yes
BY WHOM HERMAN Moore AGENCY MBMG
DATE VERIFIED 6/02/82

MEAS. POINT ABOVE LSD	____	ft.	DATE
TOTAL DEPTH BELOW LSD	____	ft.	____
PUMPING LEVEL BELOW LSD	____	ft.	____
SWL* BELOW LSD	29.48	ft.	6/02/82
YIELD IN GPM	____		____
WATER TEMP. °C	____		____
SPECIFIC COND. at 25° C	____		____

MBMG FILE NUMBER ____
ONR FILE NUMBER ____
WELL FORM NUMBER ____
MBMG WQ LAB. NUMBER ____
SYS 2000 NUMBER ____
OTHER: ____

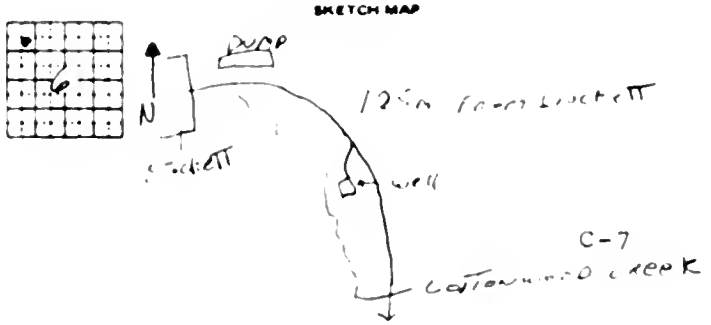
REMARKS: Drilled to 52' less 4' 10"
Drilled 6" case 11.7 feet into best water never used Huckleberries Stockett city water

*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG		
INTERVAL (FT.) FROM	TO	DESCRIPTION

SKETCH MAP



C-7

Q1

MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY CASCADE T. 18 (N) or S R. 5 (E) or W SEC. 7 TRACT BBDA

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN SUBDIVISION BLOCK LOT

OWNER'S NAME ANNA DOLENA ADDRESS Box 61 STOCKETT

PHONE NUMBER YEAR

ALT. LAND SURF. AT WELL MSL 3800 ft.
TOTAL DEPTH BELOW LSD 35 ft.
PUMPING LEVEL BELOW LSD ft.
STATIC WATER LEVEL* BELOW LSD ~~FLOW~~ ft.
YIELD IN GALLONS PER MIN. 10
HOW TESTED TIME (HR.)
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O CLAY ALLUVIUM

CASING DIA. 8 in. FROM ft. TO ft.
in. FROM ft. TO ft.
CASING TYPE STEEL
PERFORATED INTERVAL ft. TO ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC.
PUMP SIZE (HP.) TYPE
DATE WELL COMPLETED
HOW DRILLED
BY WHOM LIC.
WELL USE DOMESTIC + STOCK
SOURCE OF INFO: WELL APPROP.
DRILLER ___ OWNER X USGS ___ SCS ___
OTHER:

HAS WELL LOCATION BEEN VERIFIED YES
BY WHOM HERMAN MOORE AGENCY MBMG
DATE VERIFIED 6/04/82

			DATE
MEAS. POINT ABOVE LSD		ft.	
TOTAL DEPTH BELOW LSD		ft.	
PUMPING LEVEL BELOW LSD		ft.	
SWL* BELOW LSD	15.98	ft.	6/04/82
YIELD IN GPM			
WATER TEMP. °C	7.7°		6/04/82
SPECIFIC COND. at 25°C	983		6/04/82

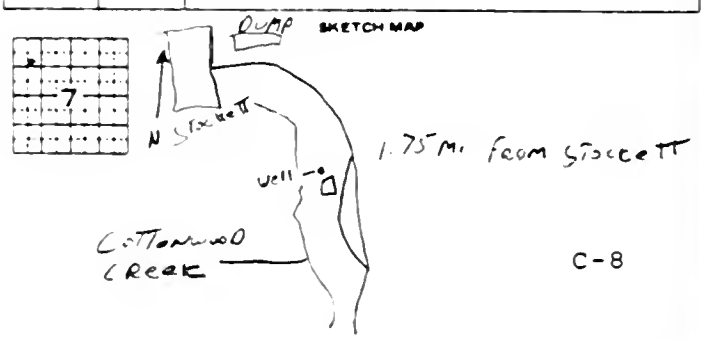
MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER:

REMARKS:

*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG		
INTERVAL (FT.) FROM	TO	DESCRIPTION



C-8

MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY CASCADE T. 18 (N) or S R. 5 (E) or W SEC. 1 TRACT KCAC

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN SUBDIVISION BLOCK LOT

OWNER'S NAME Felix MENGHINI ADDRESS Box 62 Stockett

PHONE NUMBER YEAR

ALT. LAND SURF. AT WELL MSL 3818 ft.
TOTAL DEPTH BELOW LSD 32 ft.
PUMPING LEVEL BELOW LSD ft.
STATIC WATER LEVEL* BELOW LSD 20 ft.
YIELD IN GALLONS PER MIN. 8
HOW TESTED TIME (HR.) 1
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O CLAY Alluvium

CASING DIA. 6 in. FROM ft. TO ft.
in. FROM ft. TO ft.
CASING TYPE Steel
PERFORATED INTERVAL 25 ft. TO 30 ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC.
PUMP SIZE (HP.) TYPE Jet Pump
DATE WELL COMPLETED 9/11/79
HOW DRILLED CABLE
BY WHOM [illegible] LIC. 64
WELL USE Domestic
SOURCE OF INFO: WELL APPROP. X
DRILLER OWNER USGS SCS
OTHER:

HAS WELL LOCATION BEEN VERIFIED Yes
BY WHOM HERMAN Moore AGENCY MBMG
DATE VERIFIED 6/04/82

			DATE
MEAS. POINT ABOVE LSD		ft.	
TOTAL DEPTH BELOW LSD		ft.	
PUMPING LEVEL BELOW LSD		ft.	
SWL* BELOW LSD		ft.	
YIELD IN GPM			
WATER TEMP. °C	8.3°		6/04/82
SPECIFIC COND. at 25°C	228		6/04/82

MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER:

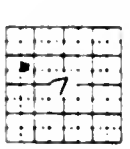
REMARKS:

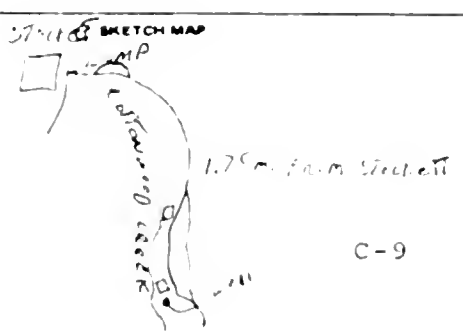
*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	25	CLAY loose Rock
25	30	Loose SANDSTONE
30	32	CLAY





C-9

MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY CASCADE T. 18 (N) or S R. 5 (E) or W SEC. 11 TRACT DCCC

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN SUBDIVISION BLOCK LOT

OWNER'S NAME MARY BETH JACOBES ADDRESS BELT MT.

PHONE NUMBER YEAR

ALT. LAND SURF. AT WELL MSL 4240 ft.
TOTAL DEPTH BELOW LSD 90 ft.
PUMPING LEVEL BELOW LSD ft.
STATIC WATER LEVEL* BELOW LSD 17 ft.
YIELD IN GALLONS PER MIN. 3+
HOW TESTED TIME (HR.)
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O CRETACEOUS KOOTENAI

CASING DIA. 6 in. FROM ft. TO ft.
in. FROM ft. TO ft.
CASING TYPE
PERFORATED INTERVAL ft. TO ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC.
PUMP SIZE (HP.) TYPE SUBMERSIBLE
DATE WELL COMPLETED
HOW DRILLED
BY WHOM LIC.
WELL USE DOMESTIC & STOCK
SOURCE OF INFO: WELL APPROP.
DRILLER ___ OWNER X USGS ___ SCS ___
OTHER:

HAS WELL LOCATION BEEN VERIFIED Yes
BY WHOM HERMAN MOORE AGENCY MBMG
DATE VERIFIED 6/07/82

		DATE
MEAS. POINT ABOVE LSD	ft.	
TOTAL DEPTH BELOW LSD	ft.	
PUMPING LEVEL BELOW LSD	ft.	
SWL* BELOW LSD	ft.	
YIELD IN GPM		
WATER TEMP. °C	7.9	6/07/82
SPECIFIC COND. at 25°C	522	6/07/82

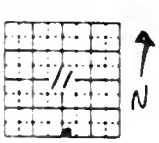
MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER:

REMARKS:

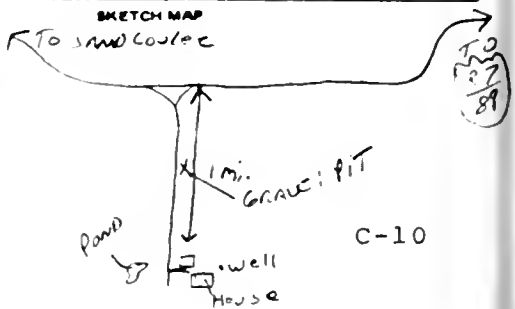
*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG		
INTERVAL (FT.)		DESCRIPTION
FROM	TO	



SKETCH MAP



C-10

MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY CASCADE T. 16 N or S R. 5 E or W SEC. 11 TRACT EDAC

LAT. ° ' " N. LONG. ° ' " W. UTM ____ N ____ E ____

TOWN ____ SUBDIVISION ____ BLOCK ____ LOT ____

OWNER'S NAME DUDLEE ADDRESS ____

PHONE NUMBER ____ YEAR ____

ALT. LAND SURF. AT WELL MSL 4380 ft.
TOTAL DEPTH BELOW LSD 75 ft.
PUMPING LEVEL BELOW LSD ____ ft.
STATIC WATER LEVEL* BELOW LSD ____ ft.
YIELD IN GALLONS PER MIN. ____
HOW TESTED ____ TIME (HR.) ____
IF F, SHUT-IN PRESS. IN PSI ____
GEOLOGICAL SOURCE OF H_2O KOOTENAI FORMATION

CASING DIA. ___ in. FROM ____ ft. TO ____ ft.
___ in. FROM ____ ft. TO ____ ft.
CASING TYPE ____
PERFORATED INTERVAL ____ ft. TO ____ ft.
____ ft. TO ____ ft.
____ ft. TO ____ ft.
PERFORATION DESC. ____
PUMP SIZE (HP.) ____ TYPE ____
DATE WELL COMPLETED ____
HOW DRILLED ____
BY WHOM ____ LIC. ____
WELL USE ____
SOURCE OF INFO: WELL APPROP. ____
DRILLER ___ OWNER ___ USGS ___ SCS ___
OTHER: ____

HAS WELL LOCATION BEEN VERIFIED Yes
BY WHOM T. Osborne AGENCY MBMG
DATE VERIFIED 8-19-82

		DATE
MEAS. POINT ABOVE LSD	____ ft.	
TOTAL DEPTH BELOW LSD	____ ft.	____
PUMPING LEVEL BELOW LSD	____ ft.	____
SWL* BELOW LSD	23.32 ft.	8-19-82
YIELD IN GPM	____	____
WATER TEMP. °C	____	____
SPECIFIC COND. at 25°C	506	8-19-82

MBMG FILE NUMBER ____
DNR FILE NUMBER ____
WELL FORM NUMBER ____
MBMG WQ LAB. NUMBER ____
SYS 2000 NUMBER ____
OTHER: ____

REMARKS: S.C. 393 @ 13.7°C
= 505.6 @ 25°C

*F = FLOWING
MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
		No Log

SKETCH MAP

↑ To stockpile

↑ N

House ☐ ○ well

C-11

MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY [illegible] T. [illegible] N or S R. [illegible] E or W SEC. [illegible] TRACT CADB

LAT. ° ' " N. LONG. ° ' " W. UTM [illegible] N [illegible] E [illegible]

TOWN [illegible] SUBDIVISION [illegible] BLOCK [illegible] LOT [illegible]

OWNER'S NAME [illegible] ADDRESS SAND COULEE MT

PHONE NUMBER [illegible] YEAR [illegible]

ALT. LAND SURF. AT WELL MSL 3660 ft.
TOTAL DEPTH BELOW LSD [illegible] ft.
PUMPING LEVEL BELOW LSD 350 ft.
STATIC WATER LEVEL* BELOW LSD [illegible] ft.
YIELD IN GALLONS PER MIN. [illegible]
HOW TESTED [illegible] TIME (HR.) [illegible]
IF F, SHUT-IN PRESS. IN PSI [illegible]
GEOLOGICAL SOURCE OF H_2O [illegible]

CASING DIA. [illegible] in. FROM [illegible] ft. TO [illegible] ft.
[illegible] in. FROM [illegible] ft. TO [illegible] ft.
CASING TYPE [illegible]
PERFORATED INTERVAL [illegible] ft. TO [illegible] ft.
[illegible] ft. TO [illegible] ft.
[illegible] ft. TO [illegible] ft.
PERFORATION DESC. [illegible]
PUMP SIZE (HP.) [illegible] TYPE [illegible]
DATE WELL COMPLETED [illegible]
HOW DRILLED ROTARY
BY WHOM [illegible] LIC. [illegible]
WELL USE STOCK
SOURCE OF INFO: WELL APPROP. /
DRILLER / OWNER [illegible] USGS [illegible] SCS [illegible]
OTHER: [illegible]

HAS WELL LOCATION BEEN VERIFIED YES
BY WHOM [illegible] AGENCY MBMG
DATE VERIFIED [illegible]

		DATE
MEAS. POINT ABOVE LSD	[illegible] ft.	
TOTAL DEPTH BELOW LSD	[illegible] ft.	[illegible]
PUMPING LEVEL BELOW LSD	[illegible] ft.	[illegible]
SWL* BELOW LSD	[illegible] ft.	[illegible]
YIELD IN GPM	[illegible]	[illegible]
WATER TEMP. °C	[illegible]	[illegible]
SPECIFIC COND. at 25°C	[illegible]	[illegible]

MBMG FILE NUMBER [illegible]
DNR FILE NUMBER [illegible]
WELL FORM NUMBER [illegible]
MBMG WQ LAB. NUMBER [illegible]
SYS 2000 NUMBER [illegible]
OTHER: [illegible]

REMARKS: [illegible]

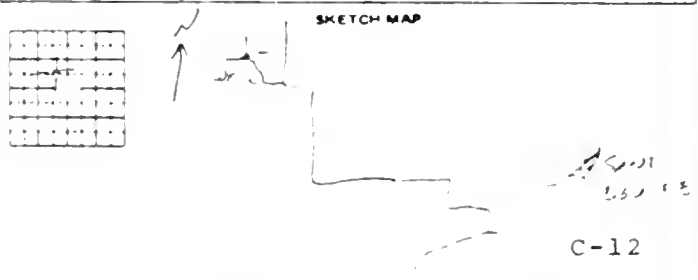
*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
[illegible]	[illegible]	[illegible]

SKETCH MAP



C-12

MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Cascade T. 19 N S R. 4 E W SEC. 12 TRACT ADDC

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN SUBDIVISION BLOCK LOT

OWNER'S NAME Gordon & Vera Mindt ADDRESS Box 62-A Sand Coulee MT

PHONE NUMBER YEAR

ALT. LAND SURF. AT WELL MSL 3420 ft.
TOTAL DEPTH BELOW LSD 136 ft.
PUMPING LEVEL BELOW LSD 136 ft.
STATIC WATER LEVEL* BELOW LSD 115 ft.
YIELD IN GALLONS PER MIN. 15
HOW TESTED BAILER TIME (HR.) 1
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O Sandstone Madison ?

CASING DIA. 6 in. FROM 0 ft. TO 120 ft.
in. FROM ft. TO ft.
CASING TYPE Steel
PERFORATED INTERVAL ft. TO ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC.
PUMP SIZE (HP.) TYPE
DATE WELL COMPLETED JAN. 28, 1974
HOW DRILLED CABLE
BY WHOM THOMAS FRANKLIN LIC. 84
WELL USE DOMESTIC - LAWN & GARDEN
SOURCE OF INFO: WELL APPROP. X
DRILLER ___ OWNER ___ USGS ___ SCS ___
OTHER:

HAS WELL LOCATION BEEN VERIFIED YES
BY WHOM Herman Moore AGENCY MBMG
DATE VERIFIED 6/09/82

		DATE
MEAS. POINT ABOVE LSD	ft.	
TOTAL DEPTH BELOW LSD	ft.	
PUMPING LEVEL BELOW LSD	ft.	
SWL* BELOW LSD	ft.	
YIELD IN GPM		
WATER TEMP. °C	13	6/09/82
SPECIFIC COND. at 25°C	2339	6/09/82

MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER:

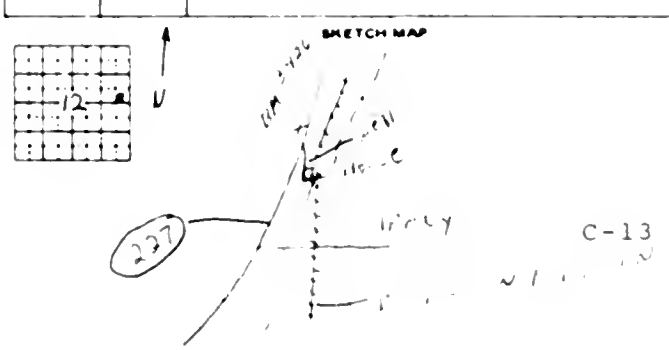
REMARKS:

*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	20	SAND, SILT
20	120	GLACIAL DRIFT
120	136	WATER BEARING SANDSTONE



C-13

MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY CASCADE T. 19 ~~N or S~~ R. 4 ~~E or W~~ SEC. 12 TRACT BDCD

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN SUBDIVISION BLOCK LOT

OWNER'S NAME JOHN PEJSKO ADDRESS STOCKETT MT. 59480
BOX 60A STAR RT. SAND COULEE

PHONE NUMBER YEAR

ALT. LAND SURF. AT WELL MSL 3482 ft.
TOTAL DEPTH BELOW LSD 72 ft.
PUMPING LEVEL BELOW LSD 50 ft.
STATIC WATER LEVEL* BELOW LSD 45 ft.
YIELD IN GALLONS PER MIN. 50
HOW TESTED TIME (HR.) 1
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O MORRISON

CASING DIA. 6⅝ in. FROM 0 ft. TO 50 ft.
5⅝ in. FROM 49 ft. TO 70 ft.
CASING TYPE
PERFORATED INTERVAL ft. TO ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC.
PUMP SIZE (HP.) TYPE SUB.
DATE WELL COMPLETED 8/26/1972
HOW DRILLED CABLE
BY WHOM PAT BYRNE LIC. 318
WELL USE DOMESTIC LAWN & GARDEN
SOURCE OF INFO: WELL APPROP.
DRILLER OWNER USGS SCS
OTHER:

HAS WELL LOCATION BEEN VERIFIED YES
BY WHOM HELMUT MOORE AGENCY M.B.M.G.
DATE VERIFIED 6/04/82

		DATE
MEAS. POINT ABOVE LSD	ft.	
TOTAL DEPTH BELOW LSD	ft.	
PUMPING LEVEL BELOW LSD	ft.	
SWL* BELOW LSD	ft.	
YIELD IN GPM		
WATER TEMP. °C	7.9	6/04/82
SPECIFIC COND. at 25°C	222	6/04/82

MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER:

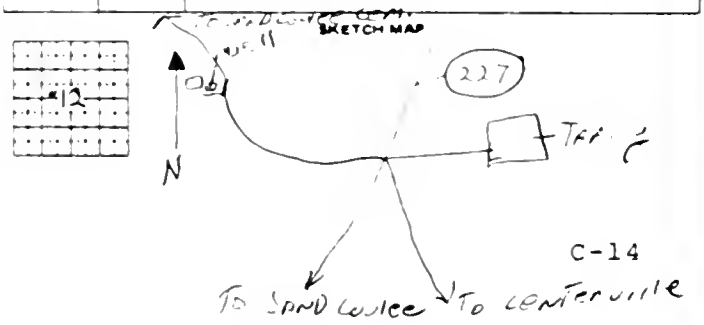
REMARKS:

*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	2	TOP SOIL
2	16	BROWN SANDY SILT
16	47	LIGHT BROWN SANDY CLAY
47	58	BROKEN SANDSTONE + WATER
58	70	GRAY GREEN SHALE



C-14

M1

MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY CASCADE T. 17 N or S R. 4 E or W SEC. 12 TRACT DBAA

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN SUBDIVISION BLOCK LOT

OWNER'S NAME RICHARD KASALA ADDRESS SAND COULEE MT

PHONE NUMBER YEAR

ALT. LAND SURF. AT WELL MSL 3440 ft.
TOTAL DEPTH BELOW LSD 158 ft.
PUMPING LEVEL BELOW LSD ft.
STATIC WATER LEVEL* BELOW LSD ft.
YIELD IN GALLONS PER MIN.
HOW TESTED BAILED TIME (HR.) 3
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O MADISON LIMESTONE

CASING DIA. 6 in. FROM 0 ft. TO 147 ft.
in. FROM ft. TO ft.
CASING TYPE IRON (20 LB/FT)
PERFORATED INTERVAL ft. TO ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC.
PUMP SIZE (HP.) TYPE
DATE WELL COMPLETED 7-3-64
HOW DRILLED CABLE TOOL
BY WHOM THOMAS FRANKLIN LIC.
WELL USE DOMESTIC
SOURCE OF INFO: WELL APPROP.
DRILLER OWNER ✓ USGS SCS
OTHER:

HAS WELL LOCATION BEEN VERIFIED YES
BY WHOM W. BENJAMIN AGENCY MBMG
DATE VERIFIED 6-9-82

			DATE
MEAS. POINT ABOVE LSD		ft.	
TOTAL DEPTH BELOW LSD		ft.	
PUMPING LEVEL BELOW LSD		ft.	
SWL* BELOW LSD	161.2a	ft.	6/9/82
YIELD IN GPM			
WATER TEMP. °C	13.1		6/9/82
SPECIFIC COND. at 25°C	612		6/9/82

MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER:

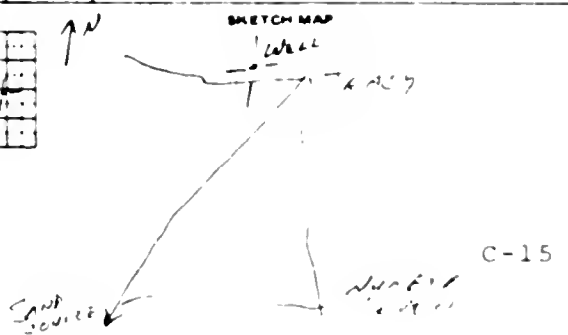
REMARKS: STD-334 @ 19.5°C
478 @ 13.1°C

*F = FLOWING
MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	20	GLACIAL DRIFT - CLAY
20	125	SHALE - GRAY
125	147	SHALE - RED
147	158	LIMESTONE
ON	MAP	3273

SKETCH MAP



C-15

MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY [illegible] T. [illegible] N or S R. [illegible] E or W SEC. [illegible] TRACT [illegible]

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN SUBDIVISION BLOCK LOT

OWNER'S NAME EVELYN A LYMAN ADDRESS SAND SPRINGS MT

PHONE NUMBER YEAR

ALT. LAND SURF. AT WELL MSL [illegible] ft.
TOTAL DEPTH BELOW LSD [illegible] ft.
PUMPING LEVEL BELOW LSD [illegible] ft.
STATIC WATER LEVEL* BELOW LSD [illegible] ft.
YIELD IN GALLONS PER MIN. [illegible]
HOW TESTED [illegible] TIME (HR.) [illegible]
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O Jurassic undiff.

CASING DIA. [illegible] in. FROM [illegible] ft. TO [illegible] ft.
[illegible] in. FROM [illegible] ft. TO [illegible] ft.
CASING TYPE
PERFORATED INTERVAL [illegible] ft. TO [illegible] ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC.
PUMP SIZE (HP.) TYPE
DATE WELL COMPLETED [illegible]
HOW DRILLED [illegible]
BY WHOM [illegible] LIC. [illegible]
WELL USE [illegible]
SOURCE OF INFO: WELL APPROP. ✓
DRILLER ___ OWNER ✓ USGS ___ SCS ___
OTHER:

HAS WELL LOCATION BEEN VERIFIED [illegible]
BY WHOM [illegible] AGENCY MBMG
DATE VERIFIED 6-9-82

		DATE
MEAS. POINT ABOVE LSD	ft.	
TOTAL DEPTH BELOW LSD	ft.	
PUMPING LEVEL BELOW LSD	ft.	
SWL* BELOW LSD	ft.	
YIELD IN GPM		
WATER TEMP. °C	12.5	6/4/82
SPECIFIC COND. at 25°C	2207	6/4/82

MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER:

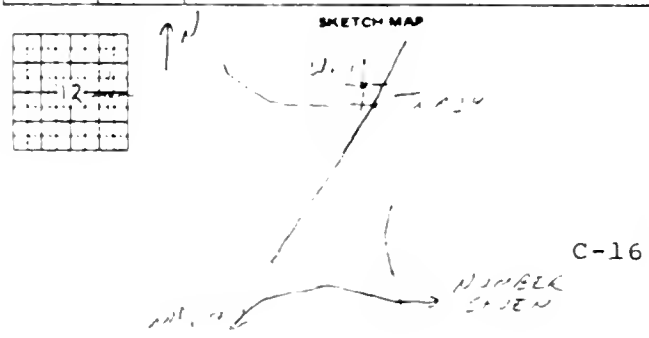
REMARKS: [illegible]
S-L 324 @ 12.5°
170 x 10 @ 12.5°

*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	20	TOPSOIL
20	30	GUMBO
30	40	SANDSTONE GRAVEL
40	58	SANDSTONE
58	60	SHALE
60	70	CALCITE-CEMENTED SANDSTONE
70	77	HARD SHALE
77	126	YELLOW RUST-CEMENTED SANDSTONE & BENTONITE
126	131	SANDSTONE



MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY CASCADE T. 20 N or S R. 4 E or W SEC. 23 TRACT AAAD

LAT. ° ' " N. LONG. ° ' " W. UTM ____ N ____ E ____

TOWN ____ SUBDIVISION ____ BLOCK ____ LOT ____

OWNER'S NAME MIKE KAVULLA ADDRESS STAR RT. ENO CASCADE MT.

PHONE NUMBER ____ YEAR ____

ALT. LAND SURF. AT WELL MSL 3440 ft.
TOTAL DEPTH BELOW LSD 120 ft.
PUMPING LEVEL BELOW LSD ____ ft.
STATIC WATER LEVEL* BELOW LSD 36 ft.
YIELD IN GALLONS PER MIN. 25
HOW TESTED BAILER TIME (HR.) 10 MIN
IF F, SHUT-IN PRESS. IN PSI ____
GEOLOGICAL SOURCE OF H_2O LIMESTONE MADISON

CASING DIA. 7 in. FROM 0 ft. TO 120 ft.
____ in. FROM ____ ft. TO ____ ft.
CASING TYPE IRON
PERFORATED INTERVAL ____ ft. TO ____ ft.
____ ft. TO ____ ft.
____ ft. TO ____ ft.
PERFORATION DESC. ____
PUMP SIZE (HP.) ____ TYPE ____
DATE WELL COMPLETED 6/20/55
HOW DRILLED CHURN DRILL
BY WHOM E. L. FLOOD LIC. ____
WELL USE DOMESTIC
SOURCE OF INFO: WELL APPROP. ____
DRILLER ___ OWNER ___ USGS ___ SCS ___
OTHER: ____

HAS WELL LOCATION BEEN VERIFIED YES
BY WHOM HERMAN MOORE AGENCY MBMG
DATE VERIFIED 6/10/82

		DATE
MEAS. POINT ABOVE LSD	____ ft.	
TOTAL DEPTH BELOW LSD	____ ft.	____
PUMPING LEVEL BELOW LSD	____ ft.	____
SWL* BELOW LSD	____ ft.	____
YIELD IN GPM	____	____
WATER TEMP. °C	12.2	6/10/82
SPECIFIC COND. at 25°C	1169	6/10/82

MBMG FILE NUMBER ____
DNR FILE NUMBER ____
WELL FORM NUMBER ____
MBMG WQ LAB. NUMBER ____
SYS 2000 NUMBER ____
OTHER: ____

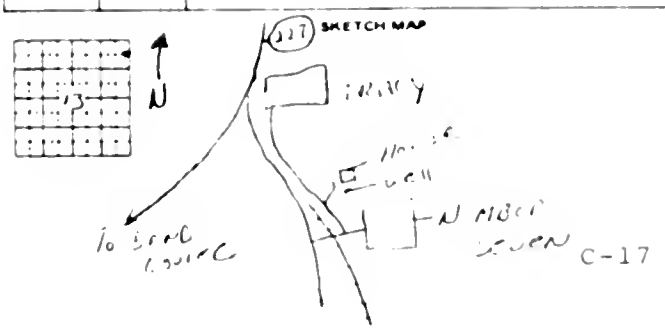
REMARKS: ____

*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	90	CLAY & GRAVEL
90	120	LIMESTONE
"0"	120	TO 350



C-17

MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY CASCADE T. 19 N or S R. 4 E or W SEC. 13 TRACT AB3

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN SUBDIVISION BLOCK LOT

OWNER'S NAME Norma Lynch ADDRESS Sand Coulee Box 71

PHONE NUMBER YEAR 1982

ALT. LAND SURF. AT WELL MSL 3430 ft.
TOTAL DEPTH BELOW LSD 168 ft.
PUMPING LEVEL BELOW LSD ft.
STATIC WATER LEVEL* BELOW LSD ft.
YIELD IN GALLONS PER MIN.
HOW TESTED TIME (HR.)
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O MADISON Limestone

CASING DIA. in. FROM ft. TO ft.
in. FROM ft. TO ft.
CASING TYPE
PERFORATED INTERVAL ft. TO ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC.
PUMP SIZE (HP.) TYPE
DATE WELL COMPLETED Over 30 years ago
HOW DRILLED
BY WHOM LIC.
WELL USE
SOURCE OF INFO: WELL APPROP.
DRILLER OWNER X USGS SCS
OTHER:

HAS WELL LOCATION BEEN VERIFIED Yes
BY WHOM T. OSBORNE AGENCY MBMG
DATE VERIFIED 6 18 82

MEAS. POINT ABOVE LSD	ft.	DATE
TOTAL DEPTH BELOW LSD	ft.	
PUMPING LEVEL BELOW LSD	ft.	
SWL* BELOW LSD	10'1 78 ft.	6-16-82
YIELD IN GPM		
WATER TEMP. °C		
SPECIFIC COND. at 25°C	700	6-18-82

MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER 82 0504
SYS 2000 NUMBER
OTHER:

REMARKS: Owner reports water quality is excellent, has always been good.

*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
		No log
		Reported to be in Madison Limestone - owner

SKETCH MAP

MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY CASCADE T. 19 (N) or S R. 4 (E) or W SEC. 13 TRACT AADB

LAT. ° ' " N. LONG. ° ' " W. UTM ____ N ____ E ____

TOWN ____ SUBDIVISION ____ BLOCK ____ LOT ____

OWNER'S NAME GEORGE SOHA ADDRESS [illegible]

PHONE NUMBER ____ YEAR ____

ALT. LAND SURF. AT WELL MSL 3440 ft.
TOTAL DEPTH BELOW LSD 212 ft.
PUMPING LEVEL BELOW LSD ____ ft.
STATIC WATER LEVEL* BELOW LSD 60 ft.
YIELD IN GALLONS PER MIN. ____
HOW TESTED ____ TIME (HR.) ____
IF F, SHUT-IN PRESS. IN PSI ____
GEOLOGICAL SOURCE OF H_2O LIMESTONE MADISON

CASING DIA. ___ in. FROM ____ ft. TO ____ ft.
___ in. FROM ____ ft. TO ____ ft.
CASING TYPE ____
PERFORATED INTERVAL ____ ft. TO ____ ft.
____ ft. TO ____ ft.
____ ft. TO ____ ft.
PERFORATION DESC. ____
PUMP SIZE (HP.) ____ TYPE ____
DATE WELL COMPLETED ____
HOW DRILLED ____
BY WHOM ____ LIC. ____
WELL USE ____
SOURCE OF INFO: WELL APPROP. ____
DRILLER ___ OWNER ___ USGS ___ SCS ___
OTHER: MIKE FAVILLA

HAS WELL LOCATION BEEN VERIFIED Yes
BY WHOM Herman Moore AGENCY MBMG
DATE VERIFIED 6/10/82

		DATE
MEAS. POINT ABOVE LSD	____ ft.	
TOTAL DEPTH BELOW LSD	____ ft.	____
PUMPING LEVEL BELOW LSD	____ ft.	____
SWL* BELOW LSD	____ ft.	____
YIELD IN GPM	____	____
WATER TEMP. °C	12°	6/10/82
SPECIFIC COND. at 25°C	619	6/10/82

MBMG FILE NUMBER ____
DNR FILE NUMBER ____
WELL FORM NUMBER ____
MBMG WQ LAB. NUMBER ____
SYS 2000 NUMBER ____
OTHER: ____

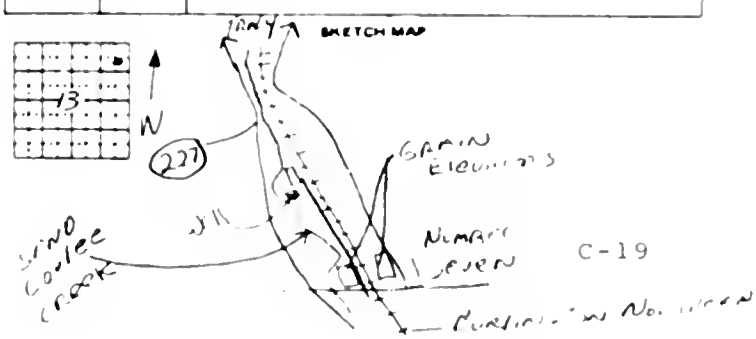
REMARKS: ____

*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG		
INTERVAL (FT.) FROM	TO	DESCRIPTION

SKETCH MAP



C-19

MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY CASCADE T. 19 N or S R. 4 E or W SEC. 13 TRACT AADD

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN SUBDIVISION BLOCK LOT

OWNER'S NAME CHARLES ENTSMINGER ADDRESS (NUMBER?) SAND COULEE MT.

PHONE NUMBER YEAR

ALT. LAND SURF. AT WELL MSL 3440 ft.
TOTAL DEPTH BELOW LSD 185 ft.
PUMPING LEVEL BELOW LSD 150 ft.
STATIC WATER LEVEL* BELOW LSD 121 ft.
YIELD IN GALLONS PER MIN. 20
HOW TESTED TIME (HR.) 2
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O LIMESTONE (MADISON)

CASING DIA. 8⅝ in. FROM 0 ft. TO 43 ft.
6⅝ in. FROM 43 ft. TO 185 ft.
CASING TYPE STEEL
PERFORATED INTERVAL ft. TO ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC.
PUMP SIZE (HP.) TYPE
DATE WELL COMPLETED 6/5/81
HOW DRILLED CABLE
BY WHOM PAT BYRNE LIC. 318
WELL USE DOMESTIC
SOURCE OF INFO: WELL APPROP. X
DRILLER OWNER USGS SCS
OTHER:

HAS WELL LOCATION BEEN VERIFIED YES
BY WHOM HERMAN MOORE AGENCY MBMG
DATE VERIFIED 6/08/82

		DATE
MEAS. POINT ABOVE LSD	ft.	
TOTAL DEPTH BELOW LSD	ft.	
PUMPING LEVEL BELOW LSD	ft.	
SWL* BELOW LSD	ft.	
YIELD IN GPM	10	6/22/82
WATER TEMP. °C	10.9	6/08/82
SPECIFIC COND. at 25°C	620	6/22/82

MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER:

REMARKS: CASING ON PLUMBING SOMETIMES, OLD WELL CAVED IN.

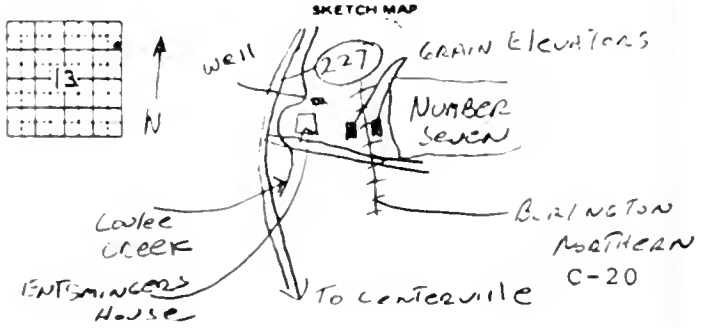
*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	10	TOP SOIL
10	30	YELLOW SANDY CLAY LOAM
30	39	SAND, GRAVEL, WATER WITH SOFT YELLOW CLAY
39	122	GRAY SILT
122	147	BROWN SANDY SILT
147	152	BROWN SAND
152	154	BROKEN SANDSTONE AND SAND, GRAVEL AND WATER
154	157	BROWN SAND
157	160	SOFT BROWN CLAY
160	168	BROWN SAND AND WATER
168	185	BROKEN LIMESTONE, SAND GRAVEL AND WATER (40 GPM±)

SKETCH MAP



MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY Cascade T. 2? N or S R. 4 E or W SEC. 13 TRACT [illegible]

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN SUBDIVISION BLOCK LOT

OWNER'S NAME George Kayulla ADDRESS Sand Coulee, MT

PHONE NUMBER YEAR

ALT. LAND SURF. AT WELL MSL 3460 ft.
TOTAL DEPTH BELOW LSD 328 ft.
PUMPING LEVEL BELOW LSD ft.
STATIC WATER LEVEL* BELOW LSD 165 ft.
YIELD IN GALLONS PER MIN. 8
HOW TESTED TIME (HR.)
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O Madison Limestone

CASING DIA. in. FROM 0 ft. TO 53 ft.
in. FROM ft. TO ft.
CASING TYPE
PERFORATED INTERVAL ft. TO ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC.
PUMP SIZE (HP.) 1 TYPE Elec. Submerg.
DATE WELL COMPLETED 7-30-60
HOW DRILLED Rotary
BY WHOM LIC.
WELL USE Domestic
SOURCE OF INFO: WELL APPROP. ✓
DRILLER OWNER ✓ USGS SCS
OTHER:

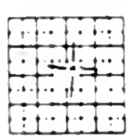
HAS WELL LOCATION BEEN VERIFIED Yes
BY WHOM W. Benjamin AGENCY MBMG
DATE VERIFIED 6-4-82
MEAS. POINT ABOVE LSD ft. DATE
TOTAL DEPTH BELOW LSD ft.
PUMPING LEVEL BELOW LSD ft.
SWL* BELOW LSD ft.
YIELD IN GPM 32 6/4/82
WATER TEMP. °C 13.3°C 6-4-82
SPECIFIC COND. at 25°C 904 6-4-82
MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER:

REMARKS: STD. 33 @ 21 °C
68 x 10.9 / 13.3 °C
Wire ? size of casing prevented
getting SWL

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	20	Fill & silty gravel
20	67	Clay
67	83	Shale
83	105	Sandstone
105	124	Hard shale rock
124	241	Limestone quartsite
		imbedded flint rock
241	328	Intermittent sandstone
		& limestone, water
3?	App.	#3336

SKETCH MAP



Beside [illegible] of Sand Coulee

C-21

*F = FLOWING

MBMG Form 182 (9/79)

MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY CASCADE T. 19 N or S R. 4 E or W SEC. 13 TRACT DADB

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN SUBDIVISION BLOCK LOT

OWNER'S NAME CHUCK PEO ADDRESS Box 94 STAR. RT. Sand Coulee

PHONE NUMBER YEAR

ALT. LAND SURF. AT WELL MSL 3457 ft.
TOTAL DEPTH BELOW LSD 176 ft.
PUMPING LEVEL BELOW LSD 175 ft.
STATIC WATER LEVEL* BELOW LSD 130 ft.
YIELD IN GALLONS PER MIN. 20
HOW TESTED PUMP TIME (HR.) 1
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O Limestone Madison

CASING DIA. 7 in. FROM 0 ft. TO 62 ft.
___ in. FROM ___ ft. TO ___ ft.
CASING TYPE Steel
PERFORATED INTERVAL ___ ft. TO ___ ft.
___ ft. TO ___ ft.
___ ft. TO ___ ft.
PERFORATION DESC.
PUMP SIZE (HP.) 1½ TYPE SUB.
DATE WELL COMPLETED 12/26/81
HOW DRILLED
BY WHOM S.T. Lyncole LIC.
WELL USE Domestic
SOURCE OF INFO: WELL APPROP. X
DRILLER ___ OWNER ___ USGS ___ SCS ___
OTHER:

HAS WELL LOCATION BEEN VERIFIED Yes
BY WHOM Herman Moore AGENCY MBMG
DATE VERIFIED 6/05/82

			DATE
MEAS. POINT ABOVE LSD	2	ft.	
TOTAL DEPTH BELOW LSD		ft.	
PUMPING LEVEL BELOW LSD		ft.	
SWL* BELOW LSD	82.56	ft.	6/05/82
YIELD IN GPM			
WATER TEMP. °C	12.9°		6/05/82
SPECIFIC COND. at 25°C	595		6/05/82

MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER:

REMARKS:

*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	6	Top Soil
6	12	Brown sandstone & some clay
12	49	Brown sandstone & some clay
49	67	gray sandstone
67	76	Brown sandstone
76	86	Gray sandstone
86	121	[illegible]
121	126	light gray [illegible]
126	176	blue [illegible]
		Water at 168-173
Top	Mad.	3371

MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY CASCADE T. 19 N or S R. 4 E or W SEC. 14 TRACT DAIA

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN SUBDIVISION BLOCK LOT

OWNER'S NAME SAND COULEE WATER USERS ADDRESS SAND COULEE, MT

PHONE NUMBER YEAR

ALT. LAND SURF. AT WELL MSL 3680 ft.
TOTAL DEPTH BELOW LSD 210 ft.
PUMPING LEVEL BELOW LSD ft.
STATIC WATER LEVEL* BELOW LSD ft.
YIELD IN GALLONS PER MIN.
HOW TESTED TIME (HR.)
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O KOOTENAI Fm

CASING DIA. 6 in. FROM 0 ft. TO 39 ft.
in. FROM ft. TO ft.
CASING TYPE IRON
PERFORATED INTERVAL ft. TO ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC.
PUMP SIZE (HP.) TYPE
DATE WELL COMPLETED 2-15-60
HOW DRILLED
BY WHOM LIC.
WELL USE
SOURCE OF INFO: WELL APPROP.
DRILLER OWNER USGS SCS
OTHER:

HAS WELL LOCATION BEEN VERIFIED YES
BY WHOM W. BENJAMIN AGENCY MBMG
DATE VERIFIED 6-5-82

			DATE
MEAS. POINT ABOVE LSD		ft.	
TOTAL DEPTH BELOW LSD		ft.	
PUMPING LEVEL BELOW LSD		ft.	
SWL* BELOW LSD		ft.	
YIELD IN GPM			
WATER TEMP. °C	11.6		6/6/82
SPECIFIC COND. at 25°C	814		6/5/82

MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER:

REMARKS: WELL #2
STD 340 @ 22.1°C
59 x 10 @ 11.6°C

*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	5	SURFACE
5	10	SANDSTONE
10	13	SHALE
13	16	SANDSTONE
16	28	SHALE
28	52	SANDSTONE
52	68	SHALE
68	70	SANDSTONE
70	76	SHALE
76	81	SANDSTONE
81	83	SHALE
83	120	SANDSTONE (YELLOW)
120	133	SHALE
133	192	SANDSTONE (WATER)
192	195	SHALE ROCK & SLATE
195	198	CLAY
198	210	SANDSTONE (WATER)

SKETCH MAP

C-23

MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY CASCADE T. 19 (N) or S R. 4 (E) or W SEC. 14 TRACT DADC-

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN SUBDIVISION BLOCK LOT

OWNER'S NAME SAND COULEE WATER USERS ADDRESS SAND COULEE MT

PHONE NUMBER YEAR

ALT. LAND SURF. AT WELL MSL 3680 ft.
TOTAL DEPTH BELOW LSD 210 ft.
PUMPING LEVEL BELOW LSD ft.
STATIC WATER LEVEL* BELOW LSD 150 ft.
YIELD IN GALLONS PER MIN. 60 GPM
HOW TESTED BAILER TIME (HR.) 1
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O MORRISON SANDSTONE

CASING DIA. 5 5/8 in. FROM 0 ft. TO 31 ft.
in. FROM ft. TO ft.
CASING TYPE IRON
PERFORATED INTERVAL ft. TO ft.
NONE ft. TO ft.
ft. TO ft.
PERFORATION DESC.
PUMP SIZE (HP.) TYPE
DATE WELL COMPLETED 10-11-73
HOW DRILLED CABLE TOOL
BY WHOM PAT BYRNE LIC.
WELL USE SAND COULEE WATER SUPPLY
SOURCE OF INFO: WELL APPROP.
DRILLER X OWNER USGS SCS
OTHER: JOHN MITAL (PRES S.C.W.U.)

HAS WELL LOCATION BEEN VERIFIED YES
BY WHOM W. GUNJAN AGENCY MBMG
DATE VERIFIED 6-5-82

		DATE
MEAS. POINT ABOVE LSD	ft.	
TOTAL DEPTH BELOW LSD	ft.	
PUMPING LEVEL BELOW LSD	ft.	
SWL* BELOW LSD	ft.	
YIELD IN GPM		
WATER TEMP. °C		
SPECIFIC COND. at 25° C		

MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER:

REMARKS: WELL #1
NOT AVAILABLE

*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	8	TOP SOIL
8	27	BROKEN ROCK (WATER)
27	40	BROWN GREY SHALE
40	48	GREY SANDSTONE
48	53	BROWN SHALE
53	68	GREY SANDSTONE
68	70	RED SHALE
70	84	GREY SHALE
84	87	HARD BLACK SHALE
87	120	GREY SANDY SHALE
120	128	GREY SANDSTONE
128	135	HARD GREY LIMESTONE
135	184	GREY SANDSTONE
184	187	WATER-SANDSTONE-COAL
187	210	BLACK CLAY-SHALE

SKETCH MAP

C-24

MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY CASCADE T. 19 N or S R. 4 E or W SEC. 14 TRACT DCCB

LAT. ° ' " N. LONG. ° ' " W. UTM ____ N ____ E ____

TOWN ____ SUBDIVISION ____ BLOCK ____ LOT ____

OWNER'S NAME CHARLES FRANTZICH ADDRESS SAND COULEE, MT

PHONE NUMBER ____ YEAR ____

ALT. LAND SURF. AT WELL MSL 3650 ft.
TOTAL DEPTH BELOW LSD 216 ft.
PUMPING LEVEL BELOW LSD 28 ft.
STATIC WATER LEVEL* BELOW LSD ____ ft.
YIELD IN GALLONS PER MIN. 13
HOW TESTED BA. AIR TIME (HR.) 1
IF F, SHUT-IN PRESS. IN PSI ____
GEOLOGICAL SOURCE OF H_2O 222 MDCD

CASING DIA. ___ in. FROM 2 ft. TO 112.5 ft.
___ in. FROM ____ ft. TO ____ ft.
CASING TYPE ____
PERFORATED INTERVAL ____ ft. TO ____ ft.
____ ft. TO ____ ft.
____ ft. TO ____ ft.
PERFORATION DESC. ____
PUMP SIZE (HP.) ____ TYPE ____
DATE WELL COMPLETED ____
HOW DRILLED ____
BY WHOM ____ LIC. ____
WELL USE ____
SOURCE OF INFO: WELL APPROP. ✓
DRILLER ___ OWNER ✓ USGS ___ SCS ___
OTHER: ____

HAS WELL LOCATION BEEN VERIFIED Yes
BY WHOM W. BENJAMIN AGENCY MBMG
DATE VERIFIED 6-3-82

		DATE
MEAS. POINT ABOVE LSD	____ ft.	
TOTAL DEPTH BELOW LSD	____ ft.	____
PUMPING LEVEL BELOW LSD	____ ft.	____
SWL* BELOW LSD	____ ft.	____
YIELD IN GPM	____	____
WATER TEMP. °C	10.5	6-3-82
SPECIFIC COND. at 25°C	1047	6-3-82

MBMG FILE NUMBER ____
DNR FILE NUMBER ____
WELL FORM NUMBER ____
MBMG WQ LAB. NUMBER ____
SYS 2000 NUMBER ____
OTHER: ____

REMARKS: STA 329 @ 20.5 °C
74 x 10 @ 10.5 °C

*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
2	112.5	Clay & gravel sand [illegible]
112.5	216	Solid lime Rock

SKETCH MAP

C-25

MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY CASCADE T. 19 (N) or S R. 4 (E) or W SEC. 21 TRACT DECO

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN SUBDIVISION BLOCK LOT

OWNER'S NAME CHARLES E. MARIS ADDRESS SAND COULEE MT

PHONE NUMBER YEAR

ALT. LAND SURF. AT WELL MSL 3830 ft.
TOTAL DEPTH BELOW LSD ~150FT ft.
PUMPING LEVEL BELOW LSD ft.
STATIC WATER LEVEL* BELOW LSD ft.
YIELD IN GALLONS PER MIN.
HOW TESTED TIME (HR.)
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O

CASING DIA. in. FROM ft. TO ft.
in. FROM ft. TO ft.
CASING TYPE
PERFORATED INTERVAL ft. TO ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC.
PUMP SIZE (HP.) TYPE
DATE WELL COMPLETED
HOW DRILLED
BY WHOM LIC.
WELL USE DOMESTIC
SOURCE OF INFO: WELL APPROP.
DRILLER OWNER ✓ USGS SCS
OTHER:

HAS WELL LOCATION BEEN VERIFIED YES
BY WHOM W. BENJAMIN AGENCY MBMG
DATE VERIFIED 6-9-82

		DATE
MEAS. POINT ABOVE LSD	ft.	
TOTAL DEPTH BELOW LSD	ft.	
PUMPING LEVEL BELOW LSD	ft.	
SWL* BELOW LSD	ft.	
YIELD IN GPM		
WATER TEMP. °C	13.4	6-4-82
SPECIFIC COND. at 25°C	915	6-4-82

MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER:

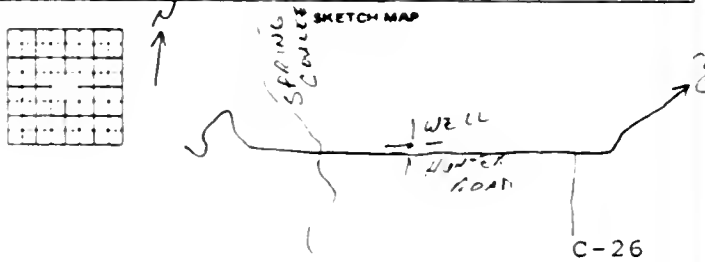
REMARKS: S-D 331 321.1°C
S.I. 69x10@ 13.4°C
WATER LEVEL NOT AVAILABLE

*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG		
INTERVAL (FT.) FROM	TO	DESCRIPTION
		NO LOG
		AVAILABLE

SKETCH MAP



MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY [illegible] T. 1 N or S R. 4 E or W SEC. [illegible] TRACT [illegible]

LAT. ° ' " N. LONG. ° ' " W. UTM ____ N ____ E ____

TOWN ____ SUBDIVISION ____ BLOCK ____ LOT ____

OWNER'S NAME GERALD SWARTZENBERGER ADDRESS [illegible]

PHONE NUMBER ____ YEAR ____

ALT. LAND SURF. AT WELL MSL 3765 ft.
TOTAL DEPTH BELOW LSD 248 ft.
PUMPING LEVEL BELOW LSD ____ ft.
STATIC WATER LEVEL* BELOW LSD 170 ft.
YIELD IN GALLONS PER MIN. 3
HOW TESTED BAILER TIME (HR.) 1
IF F, SHUT-IN PRESS. IN PSI ____
GEOLOGICAL SOURCE OF H_2O KK

CASING DIA. 8 in. FROM 0 ft. TO 14 ft.
____ in. FROM ____ ft. TO ____ ft.
CASING TYPE STEEL (10 LB/FT)
PERFORATED INTERVAL ____ ft. TO ____ ft.
NONE ____ ft. TO ____ ft.
OPEN END ____ ft. TO ____ ft.
PERFORATION DESC. ____
PUMP SIZE (HP.) ____ TYPE ____
DATE WELL COMPLETED 11-12-73
HOW DRILLED CABLE TOOL
BY WHOM THOMAS B. FRANKLIN LIC. 84
WELL USE DOMESTIC
SOURCE OF INFO: WELL APPROP. ____
DRILLER ✓ OWNER ✓ USGS ____ SCS ____
OTHER: ____

HAS WELL LOCATION BEEN VERIFIED YES
BY WHOM J. BENJAMIN AGENCY MBMG
DATE VERIFIED 6-2-82

		DATE
MEAS. POINT ABOVE LSD	____ ft.	
TOTAL DEPTH BELOW LSD	____ ft.	
PUMPING LEVEL BELOW LSD	____ ft.	
SWL* BELOW LSD	____ ft.	
YIELD IN GPM	____	
WATER TEMP. °C	____	
SPECIFIC COND. at 25°C	____	

MBMG FILE NUMBER ____
DNR FILE NUMBER ____
WELL FORM NUMBER ____
MBMG WQ LAB. NUMBER ____
SYS 2000 NUMBER ____
OTHER: ____

REMARKS: OWNER NOT IN - ALLOW ME TO TAKE SWL

*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG		
INTERVAL (FT.) FROM	TO	DESCRIPTION
0	1	LOOSE SAND ROCK
1	15	RED SHALE
15	22	CLAY
22	25	HARD SANDSTONE
25	32	RED SHALE
32	36	HARD SANDSTONE
36	50	RED SHALE
50	59	GRAY SHALE
59	112	HARD SANDSTONE [illegible] 1 GPM WATER
112	135	GRAY SHALE
135	165	SOFT SANDSTONE
165	168	RED SHALE
168	220	CLAY MIXED WITH SAND
220	248	MORRISON SANDSTONE W/YIELD OF APPROX. 3 GPM WATER - COMP. @ 248

SKETCH MAP

N

[illegible] SAND [illegible]

[illegible]

C-27

MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY VALLEY T. 28 N or S R. 46 E or W SEC. 23 TRACT SW1/4

LAT. ° ' " N. LONG. ° ' " W. UTM ____ N ____ E ____

TOWN ____ SUBDIVISION ____ BLOCK ____ LOT ____

OWNER'S NAME HARVEY LAKOSKE ADDRESS SAINT LOUISE, MT

PHONE NUMBER ____ YEAR ____

ALT. LAND SURF. AT WELL MSL 3680 ft.
TOTAL DEPTH BELOW LSD 400 ft.
PUMPING LEVEL BELOW LSD ____ ft.
STATIC WATER LEVEL* BELOW LSD 0 ft.
YIELD IN GALLONS PER MIN. ____
HOW TESTED ____ TIME (HR.) ____
IF F, SHUT-IN PRESS. IN PSI ____
GEOLOGICAL SOURCE OF H_2O ____

CASING DIA. 6 in. FROM 0 ft. TO 30 ft.
____ in. FROM ____ ft. TO ____ ft.
CASING TYPE ST
PERFORATED INTERVAL ____ ft. TO ____ ft.
____ ft. TO ____ ft.
____ ft. TO ____ ft.
PERFORATION DESC. ____
PUMP SIZE (HP.) ____ TYPE ____
DATE WELL COMPLETED ____
HOW DRILLED ____
BY WHOM ____ LIC. ____
WELL USE LIVESTOCK
SOURCE OF INFO: WELL APPROP. ____
DRILLER ___ OWNER X USGS ___ SCS ___
OTHER: ____

HAS WELL LOCATION BEEN VERIFIED YES
BY WHOM J. RENTHAN AGENCY MBMG
DATE VERIFIED 6-9-82

		DATE
MEAS. POINT ABOVE LSD	____ ft.	
TOTAL DEPTH BELOW LSD	____ ft.	____
PUMPING LEVEL BELOW LSD	____ ft.	____
SWL* BELOW LSD	____ ft.	____
YIELD IN GPM	____	____
WATER TEMP. °C	14.2	6/9/82
SPECIFIC COND. at 25°C	627	6/9/82

MBMG FILE NUMBER ____
DNR FILE NUMBER ____
WELL FORM NUMBER ____
MBMG WQ LAB. NUMBER ____
SYS 2000 NUMBER ____
OTHER: ____

REMARKS: [illegible] 14.2°C
[illegible] 627

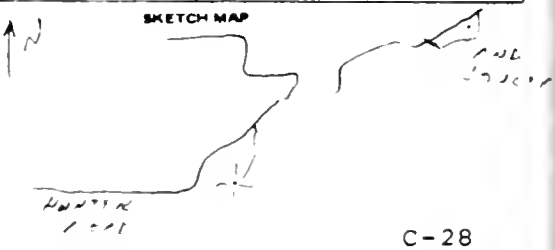
H2O TEMP - 11.9°C SAMPLING DATE

*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
		NO LOG AVAILABLE



MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY [illegible] T. [illegible] N or S R. [illegible] E or W SEC. [illegible] TRACT [illegible]

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN SUBDIVISION BLOCK LOT

OWNER'S NAME [illegible] ADDRESS [illegible]

PHONE NUMBER YEAR

ALT. LAND SURF. AT WELL MSL 3775 ft.
TOTAL DEPTH BELOW LSD 586 ft.
PUMPING LEVEL BELOW LSD 586 ft.
STATIC WATER LEVEL* BELOW LSD 515 ft.
YIELD IN GALLONS PER MIN. 5
HOW TESTED PUMP TIME (HR.) 2
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O Kootenai fm. Jurassic Ellis?, & Madison
CASING DIA. 6 5/8 in. FROM 0 ft. TO 20 ft.
in. FROM ft. TO ft.
CASING TYPE 2-20' STEEL
PERFORATED INTERVAL ft. TO ft.
NONE OPEN END ft. TO ft.
ft. TO ft.
PERFORATION DESC.
PUMP SIZE (HP.) TYPE
DATE WELL COMPLETED 6-26-75
HOW DRILLED AIR ROTARY
BY WHOM A-1 DRILLING-KEITH MORTON LIC. 275
WELL USE DOMESTIC
SOURCE OF INFO: WELL APPROP. ____
DRILLER ✓ OWNER ✓ USGS ___ SCS ___
OTHER:

HAS WELL LOCATION BEEN VERIFIED YES
BY WHOM W. BENJAMIN AGENCY MBMG
DATE VERIFIED 6-2-82

		DATE
MEAS. POINT ABOVE LSD	ft.	
TOTAL DEPTH BELOW LSD	ft.	
PUMPING LEVEL BELOW LSD	ft.	
SWL* BELOW LSD	ft.	
YIELD IN GPM		
WATER TEMP. °C	12.1	6-2-82
SPECIFIC COND. at 25°C	621	6-2-82

MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER:

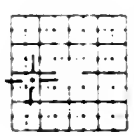
REMARKS: [illegible]
[illegible]
SWL [illegible] @ 20.2°C
515 @ 18.1°C

*F = FLOWING
MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	3	[illegible]
3	5	RED SHALE
5	18	GREY SH- BRWN
18	19	YELLOW CLAY
19	24	GREY SHALE
24	49	RED SHALE
49	55	GREY SHALE
55	57	RED SHALE
57	95	GREY SHALE
95	98	YELLOW SANDSTONE
98	147	GREY SHALE
147	175	RED SHALE
175	178	GREY SHALE
178	187	RED SHALE
187	197	GREY SHALE
197	230	GREY SANDSTONE [illegible]
230	239	COAL (BLACK)
239	250	GREY SANDSTONE
250	415	GREY SHALE
415	456	GREY SHEAR-SHARK-[illegible]
456	515	[illegible] LIME (MAL SON [illegible]
515	586	SOLID DRILLING NO [illegible]
		NO MUL NO WATER NO [illegible]
		515-586)
[illegible]	MAN	[illegible]

SKETCH MAP



[illegible]

C-29

MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY CASCADE T. 19 (N) S R. 4 (E) W SEC. 27 TRACT ACBD

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN SUBDIVISION BLOCK LOT

OWNER'S NAME HARMAN YOUNG ADDRESS SAND COULEE MT
FILED UNDER MURRAY M. SUTHERLIN

PHONE NUMBER YEAR

ALT. LAND SURF. AT WELL MSL 3825 ft.
TOTAL DEPTH BELOW LSD 423 ft.
PUMPING LEVEL BELOW LSD ft.
STATIC WATER LEVEL* BELOW LSD ? ft.
YIELD IN GALLONS PER MIN.
HOW TESTED TIME (HR.)
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O
Kootenai Fm and
Terrace Landslide
CASING DIA. 6 in. FROM 0 ft. TO 70 ft.
in. FROM ft. TO ft.
CASING TYPE IRON
PERFORATED INTERVAL ft. TO ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC.
PUMP SIZE (HP.) TYPE ELECTRIC
DATE WELL COMPLETED 4-25-61
HOW DRILLED ROTARY
BY WHOM JOHNSEN DRILLING LIC.
WELL USE DOMESTIC
SOURCE OF INFO: WELL APPROP.
DRILLER ✓ OWNER ✓ USGS SCS
OTHER:

HAS WELL LOCATION BEEN VERIFIED YES
BY WHOM W. GENJAN II AGENCY MBMG
DATE VERIFIED 6-5-82

		DATE
MEAS. POINT ABOVE LSD	ft.	
TOTAL DEPTH BELOW LSD	ft.	
PUMPING LEVEL BELOW LSD	ft.	
SWL* BELOW LSD	ft.	
YIELD IN GPM		
WATER TEMP. °C		
SPECIFIC COND. at 25°C		

MBMG FILE NUMBER
ONR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER:

REMARKS: WELL WAS UNDER WATER
N RECORD FROM MR. SUTHERLIN
SW. QUARTER

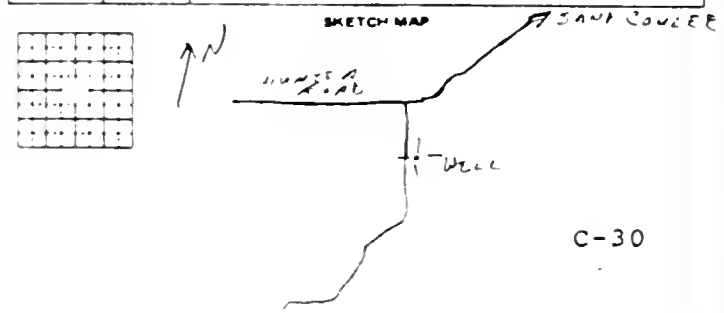
*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	14	CLAY
14	22	RED BED
22	24	SANDSTONE
24	29	RED BED
29	41	SHALE ROCK
41	47	SHALE - GREY
47	64	SOFT - RED BED
64	99	SHALE ROCK
99	101	SANDSTONE
101	112	SHALE ROCK
112	122	SHALE ROCK & SANDSTONE STREAKS
122	145	SANDSTONE
145	148	SHALE ROCK
148	163	SHALE ROCK & SANDSTONE
163	172	RED BED
172	184	SANDY SHALE ROCK - GRAY
184	214	RED BED
214	223	SANDY SHALE ROCK
223	233	RED BED
233	245	SANDSTONE & WATER - 5 GPM
245	253	COAL
253	260	BLUE SHALE ROCK
260	274	YELLOW SHALE ROCK
274	401	SHALE ROCK CONGLOMERATION
401	423	SANDSTONE

SKETCH MAP



MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY CASCADE T. 19 N R. 4 E W SEC. 26 TRACT DCBA

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN SUBDIVISION BLOCK LOT

OWNER'S NAME ROBERT KLASNER ADDRESS STOCKETT MT. 59480

PHONE NUMBER YEAR

ALT. LAND SURF. AT WELL MSL 3625 ft.
TOTAL DEPTH BELOW LSD 830 ft.
PUMPING LEVEL BELOW LSD AIR PUMPING ft.
STATIC WATER LEVEL* BELOW LSD 500 ft.
YIELD IN GALLONS PER MIN. 50
HOW TESTED AIR BLOWER TIME (HR.)
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O LIMESTONE MADISON

CASING DIA. 6" in. FROM 0 ft. TO 60 ft.
in. FROM ft. TO ft.
CASING TYPE STEEL
PERFORATED INTERVAL ft. TO ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC.
PUMP SIZE (HP.) TYPE
DATE WELL COMPLETED 12/14/77
HOW DRILLED FORWARD ROTARY
BY WHOM AXE DRILLING LIC. 247
WELL USE MUNICIPAL
SOURCE OF INFO: WELL APPROP. X
DRILLER OWNER USGS SCS
OTHER:

HAS WELL LOCATION BEEN VERIFIED YES
BY WHOM HERMAN MOORE AGENCY MBMG
DATE VERIFIED 6/01/82

		DATE
MEAS. POINT ABOVE LSD	ft.	
TOTAL DEPTH BELOW LSD	ft.	
PUMPING LEVEL BELOW LSD	ft.	
SWL* BELOW LSD	ft.	
YIELD IN GPM		
WATER TEMP. °C		
SPECIFIC COND. at 25°C		

MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER:

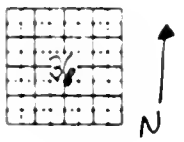
REMARKS: SHOULD BE FLOWING BY THE END OF JULY '82

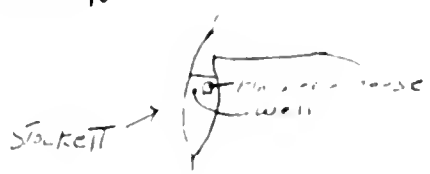
*F = FLOWING
MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	2	TOP SOIL
2	14	CLAY WITH GRAVEL
14	56	SHALE
56	830	LIMESTONE
		450' APPROX 10 GPM
		700' 10-15 GPM
		APPROX 50 GPM

SKETCH MAP





C-31

M4

MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY CASCADE T. 19 N R. 5 E W SEC. 7 TRACT BDDC

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN SUBDIVISION BLOCK LOT

OWNER'S NAME GEORGE HEAL well 2 ADDRESS SAND COULEE

PHONE NUMBER YEAR

ALT. LAND SURF. AT WELL MSL 3455 ft.
TOTAL DEPTH BELOW LSD 220 ft.
PUMPING LEVEL BELOW LSD ft.
STATIC WATER LEVEL* BELOW LSD 6.33 ft.
YIELD IN GALLONS PER MIN.
HOW TESTED TIME (HR.)
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O Well into limestone
However must have recharge from stream 10' away (?)
CASING DIA. 6 in. FROM ft. TO ft.
in. FROM ft. TO ft.
CASING TYPE Steel
PERFORATED INTERVAL ft. TO ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC.
PUMP SIZE (HP.) TYPE
DATE WELL COMPLETED
HOW DRILLED
BY WHOM LIC.
WELL USE Stock
SOURCE OF INFO: WELL APPROP.
DRILLER OWNER X USGS SCS
OTHER:

HAS WELL LOCATION BEEN VERIFIED Yes
BY WHOM HERMAN MOORE AGENCY MBMG
DATE VERIFIED 6/04/82

		DATE
MEAS. POINT ABOVE LSD	1.5 ft.	
TOTAL DEPTH BELOW LSD	ft.	
PUMPING LEVEL BELOW LSD	ft.	
SWL* BELOW LSD	6.33 ft.	6/04/82
YIELD IN GPM		
WATER TEMP. °C	13.7	6/04/82
SPECIFIC COND. at 25°C	1667	6/04/82

MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER:

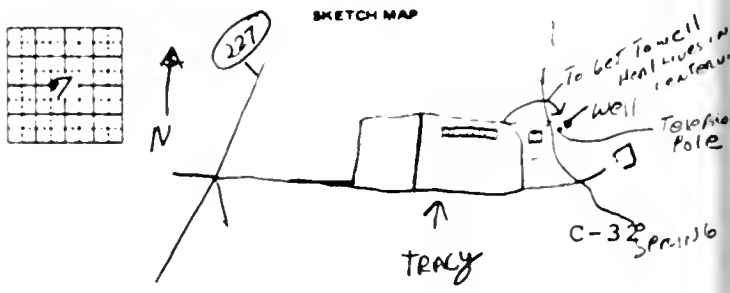
REMARKS:

*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG		
INTERVAL (FT.)		DESCRIPTION
FROM	TO	

SKETCH MAP



MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY CASCADE T. 21 N or S R. 5 E or W SEC. 7 TRACT BUB

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN SUBDIVISION BLOCK LOT

OWNER'S NAME JIM ERICKSON ADDRESS AND CITY MT.

PHONE NUMBER YEAR

ALT. LAND SURF. AT WELL MSL 3453 ft.
TOTAL DEPTH BELOW LSD 314 ft.
PUMPING LEVEL BELOW LSD ft.
STATIC WATER LEVEL* BELOW LSD ft.
YIELD IN GALLONS PER MIN. 35
HOW TESTED TIME (HR.)
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O LIMESTONE MADISON

CASING DIA. 6 in. FROM ft. TO ft.
in. FROM ft. TO ft.
CASING TYPE STEEL
PERFORATED INTERVAL ft. TO ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC.
PUMP SIZE (HP.) TYPE
DATE WELL COMPLETED
HOW DRILLED
BY WHOM PAT BYRNE LIC.
WELL USE
SOURCE OF INFO: WELL APPROP.
DRILLER OWNER X USGS SCS
OTHER:

HAS WELL LOCATION BEEN VERIFIED Yes
BY WHOM HERMAN MOORE AGENCY MBMG
DATE VERIFIED 6/02/22

		DATE
MEAS. POINT ABOVE LSD	ft.	
TOTAL DEPTH BELOW LSD	ft.	
PUMPING LEVEL BELOW LSD	ft.	
SWL* BELOW LSD	ft.	
YIELD IN GPM		
WATER TEMP. °C		
SPECIFIC COND. at 25°C		

MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER:

REMARKS: WELL IS PART OF TRACY WATER SYSTEM WHICH HAS TWO WELLS IN SYSTEM

*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG		
INTERVAL (FT.) FROM	TO	DESCRIPTION

SKETCH MAP

C-33

M5

MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY CASCADE T. 19 (N) or S R. 5 (E) or W SEC. 18 TRACT BACB

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN SUBDIVISION BLOCK LOT

OWNER'S NAME ANDY TESINSKY ADDRESS SAND COULEE MT.

PHONE NUMBER YEAR

ALT. LAND SURF. AT WELL MSL 3460 ft.
TOTAL DEPTH BELOW LSD 185 ft.
PUMPING LEVEL BELOW LSD ft.
STATIC WATER LEVEL* BELOW LSD ft.
YIELD IN GALLONS PER MIN.
HOW TESTED TIME (HR.)
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O LIMESTONE (2)

CASING DIA. 6 in. FROM ft. TO ft.
in. FROM ft. TO ft.
CASING TYPE STEEL
PERFORATED INTERVAL ft. TO ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC.
PUMP SIZE (HP.) TYPE
DATE WELL COMPLETED
HOW DRILLED
BY WHOM LIC.
WELL USE DOMESTIC
SOURCE OF INFO: WELL APPROP.
DRILLER ___ OWNER X USGS ___ SCS ___
OTHER:

HAS WELL LOCATION BEEN VERIFIED YES
BY WHOM HERMAN MOORE AGENCY MBMG
DATE VERIFIED 6/10/82

		DATE
MEAS. POINT ABOVE LSD	ft.	
TOTAL DEPTH BELOW LSD	ft.	
PUMPING LEVEL BELOW LSD	ft.	
SWL* BELOW LSD	148.68 ft.	6/10/82
YIELD IN GPM		
WATER TEMP. °C	15.2	6/10/82
SPECIFIC COND. at 25°C	617	6/10/82

MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER:

REMARKS:

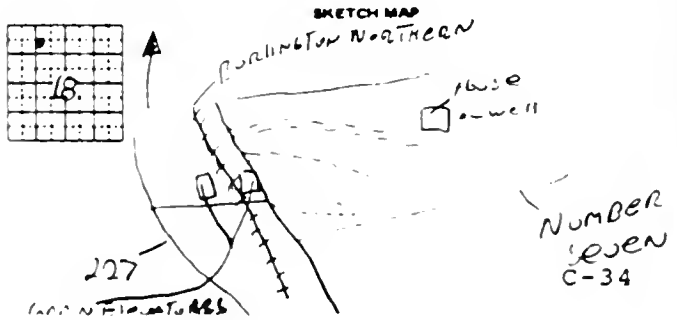
*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION

SKETCH MAP



MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY CASCADE T. 19 ~~North~~ R. 5 ~~East~~ SEC. 18 TRACT BLAD

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN SUBDIVISION BLOCK LOT

OWNER'S NAME LARRY McEWEN ADDRESS (NUMBER) SAND COULEE MT.

PHONE NUMBER YEAR

ALT. LAND SURF. AT WELL MSL 3457 ft.
TOTAL DEPTH BELOW LSD 162 ft.
PUMPING LEVEL BELOW LSD 155 ft.
STATIC WATER LEVEL* BELOW LSD 143 ft.
YIELD IN GALLONS PER MIN. 40
HOW TESTED BAILER TIME (HR.) 2
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O LIMESTONE MADISON

CASING DIA. 6 in. FROM 0 ft. TO 162 ft.
___ in. FROM ___ ft. TO ___ ft.
CASING TYPE
PERFORATED INTERVAL ___ ft. TO ___ ft.
___ ft. TO ___ ft.
___ ft. TO ___ ft.
PERFORATION DESC.
PUMP SIZE (HP.) ___ TYPE
DATE WELL COMPLETED 3/7/62
HOW DRILLED CHURN DRILL
BY WHOM PAT BYRNE LIC. 135
WELL USE DOMESTIC
SOURCE OF INFO: WELL APPROP. X
DRILLER ___ OWNER ___ USGS ___ SCS ___
OTHER:

HAS WELL LOCATION BEEN VERIFIED Yes
BY WHOM HERMAN MOORE AGENCY MBMG
DATE VERIFIED 6/10/82

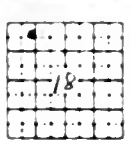
MEAS. POINT ABOVE LSD	___ ft.	DATE
TOTAL DEPTH BELOW LSD	___ ft.	___
PUMPING LEVEL BELOW LSD	___ ft.	___
SWL* BELOW LSD	___ ft.	___
YIELD IN GPM	___	___
WATER TEMP. °C	11.7°	6/10/82
SPECIFIC COND. at 25°C	634	6/10/82

MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER:

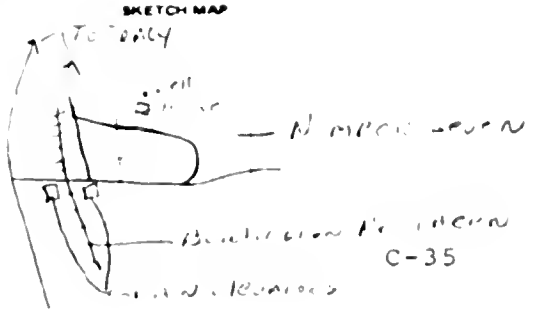
REMARKS: METALLIC TASTE SINCE CHARLES ENTSMINGER'S OLD WELL CAVED IN.

*F = FLOWING
MBMG Form 182 (9/79)

LITHOLOGIC LOG		
INTERVAL (FT.) FROM	TO	DESCRIPTION
0	20	TOP SOIL
20	30	YELLOW SHALE
30	38	BENTONITE
38	48	YELLOW SHALE
48	65	HARD SAND ROCK
65	85	GRAY SHALE
85	89	SAND STONE
89	105	GRAY BROKEN SHALE & SANDSTONE
105	110	GREEN SHALE
110	115	SAND STONE WATER (2 GPM)
115	122	SAND STONE LOST WATER
122	130	HARD SAND ROCK
130	136	GRAY LIME
136	140	SANDSTONE
140	143	QUARTZ
143	147	HARD GRAY SHALE
147	153	SANDSTONE
153	162	LIMESTONE
		WATER (40 GPM)
T. P.	TD	32 SL



SKETCH MAP



C-35

1146

MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY CASCADE T. 19 (N) ~~S~~ R. 5 E ~~or W~~ SEC. 18 TRACT CBDD

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN SUBDIVISION BLOCK LOT

OWNER'S NAME TERRY NET ADDRESS Box 95 STAR RT. Stockett

PHONE NUMBER YEAR

ALT. LAND SURF. AT WELL MSL 3455 ft.
TOTAL DEPTH BELOW LSD 175' ft.
PUMPING LEVEL BELOW LSD 172 ft.
STATIC WATER LEVEL* BELOW LSD 137 ft.
YIELD IN GALLONS PER MIN. 40
HOW TESTED TIME (HR.) 1
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O MADISON LIMESTONE

CASING DIA. 8 in. FROM 0 ft. TO 100 ft.
6 5/8 in. FROM 100 ft. TO 175 ft.
CASING TYPE Steel
PERFORATED INTERVAL ft. TO ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC.
PUMP SIZE (HP.) TYPE
DATE WELL COMPLETED
HOW DRILLED
BY WHOM LIC.
WELL USE Domestic & Stock
SOURCE OF INFO: WELL APPROP. \
DRILLER ___ OWNER ___ USGS ___ SCS ___
OTHER:

HAS WELL LOCATION BEEN VERIFIED
BY WHOM Herman Moore AGENCY MBMG
DATE VERIFIED 6/05/82

			DATE
MEAS. POINT ABOVE LSD		ft.	
TOTAL DEPTH BELOW LSD		ft.	
PUMPING LEVEL BELOW LSD	172	ft.	6/05/82
SWL* BELOW LSD	79.76	ft.	6/19/82
YIELD IN GPM	11.25		6/19/82
WATER TEMP. °C	12.5		6/05/82
SPECIFIC COND. at 25°C	597		6/19/22

MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER:

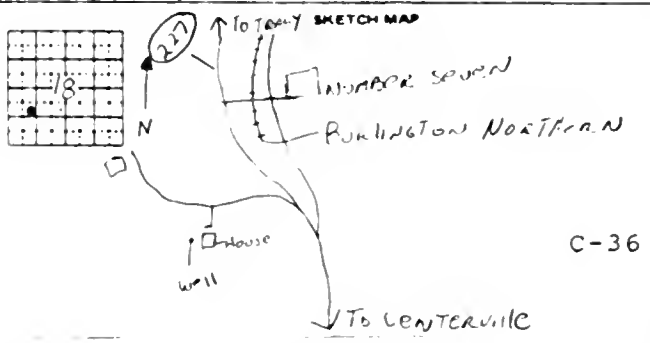
REMARKS:

*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	2	Top Soil
2	20	Broken Sandstone
20	35	Yellow Clay
36	40	Sandstone
40	49	Yellow Clay
49	54	Broken Sandstone
54	64	Broken Sandstone
64	67	Broken Grey Sandstone
67	70	Grey Shale
70	85	Grey Shale
85	105	Hard Grey limestone
105	175	Limestone



C-36

MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY CASCADE T. 19 N or S R. 5 E or W SEC. 18 TRACT DRAB

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN SUBDIVISION BLOCK LOT

OWNER'S NAME KUUY MARKO ADDRESS Sand Coulee

PHONE NUMBER YEAR

ALT. LAND SURF. AT WELL MSL 3455 ft.
TOTAL DEPTH BELOW LSD 190 ft.
PUMPING LEVEL BELOW LSD ft.
STATIC WATER LEVEL* BELOW LSD 145 ft.
YIELD IN GALLONS PER MIN.
HOW TESTED TIME (HR.)
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O Lime stone Mission

CASING DIA. 6 in. FROM 0 ft. TO 60 ft.
in. FROM ft. TO ft.
CASING TYPE Steel
PERFORATED INTERVAL ft. TO ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC.
PUMP SIZE (HP.) TYPE
DATE WELL COMPLETED 1940
HOW DRILLED
BY WHOM MAH.T LIC.
WELL USE Domestic & Stock
SOURCE OF INFO: WELL APPROP.
DRILLER OWNER X USGS SCS
OTHER:

HAS WELL LOCATION BEEN VERIFIED Yes
BY WHOM HERMAN Moore AGENCY MBMG
DATE VERIFIED 6/09/82

			DATE
MEAS. POINT ABOVE LSD		ft.	
TOTAL DEPTH BELOW LSD		ft.	
PUMPING LEVEL BELOW LSD		ft.	
SWL* BELOW LSD		ft.	
YIELD IN GPM			
WATER TEMP. °C	12.9		6/09/82
SPECIFIC COND. at 25°C	587		6/09/82

MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER:

REMARKS:

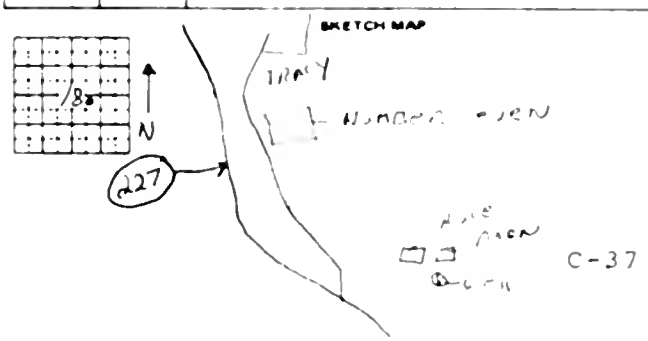
*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	135	?
135	190	Limestone
TD?	MM	? ? ?

SKETCH MAP



M7

MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY CASCADE T. 19 (N) or S R. 5 (E) or W SEC. 18 TRACT DCDC

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN SUBDIVISION BLOCK LOT

OWNER'S NAME Centerville Senior Citizens Blg. ADDRESS SAND COULEE

PHONE NUMBER YEAR

ALT. LAND SURF. AT WELL MSL 3475 ft.
TOTAL DEPTH BELOW LSD 200 ft.
PUMPING LEVEL BELOW LSD ~~122.92~~ ft.
STATIC WATER LEVEL* BELOW LSD ft.
YIELD IN GALLONS PER MIN.
HOW TESTED TIME (HR.)
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O LIMESTONE MADISON

CASING DIA. 6 in. FROM ft. TO ft.
in. FROM ft. TO ft.
CASING TYPE PLASTIC
PERFORATED INTERVAL ft. TO ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC.
PUMP SIZE (HP.) TYPE
DATE WELL COMPLETED
HOW DRILLED
BY WHOM LIC.
WELL USE DOMESTIC
SOURCE OF INFO: WELL APPROP.
DRILLER OWNER USGS SCS
OTHER: HCAL - PRESENT WHEN DRILLED

HAS WELL LOCATION BEEN VERIFIED Yes
BY WHOM Norman Moore AGENCY MBMG
DATE VERIFIED 6/09/82

		DATE
MEAS. POINT ABOVE LSD	ft.	
TOTAL DEPTH BELOW LSD	ft.	
PUMPING LEVEL BELOW LSD	ft.	
SWL* BELOW LSD	122.92 ft.	6/09/82
YIELD IN GPM		
WATER TEMP. °C	7.1°	6/09/82
SPECIFIC COND. at 25°C	2292	6/09/82

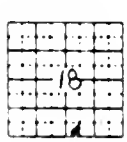
MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER:

REMARKS: DO NOT USE WATER FOR DRINKING FOAMY WATER COMING OUT BUT WATER IS USE FOR TANK (CA)

*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG		
INTERVAL (FT.)		DESCRIPTION
FROM	TO	



SKETCH MAP

C-38

MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY CASCADE T. 19 (N) or S R. 5 (E) or W SEC. 17 TRACT AADC

LAT. ° ' " N. LONG. ° ' " W. UTM ____ N ____ E ____

TOWN ____ SUBDIVISION ____ BLOCK ____ LOT ____

OWNER'S NAME THOMAS BEHRENT ADDRESS STARR GREAT FALLS MT

PHONE NUMBER ____ YEAR ____

ALT. LAND SURF. AT WELL MSL 3480 ft.
TOTAL DEPTH BELOW LSD 107 ft.
PUMPING LEVEL BELOW LSD 95 ft.
STATIC WATER LEVEL* BELOW LSD 31 ft.
YIELD IN GALLONS PER MIN. 7
HOW TESTED BAILER TIME (HR.) 2
IF F, SHUT-IN PRESS. IN PSI ____
GEOLOGICAL SOURCE OF H_2O LIMESTONE MADISON

CASING DIA. 5½ in. FROM 0 ft. TO 100 ft.
____ in. FROM ____ ft. TO ____ ft.
CASING TYPE STEEL
PERFORATED INTERVAL 31 ft. TO 35 ft.
____ ft. TO ____ ft.
____ ft. TO ____ ft.
PERFORATION DESC. TORCH
PUMP SIZE (HP.) ____ TYPE ____
DATE WELL COMPLETED 3/17/78
HOW DRILLED CABLE
BY WHOM PAT BYRNE LIC. 135
WELL USE DOMESTIC
SOURCE OF INFO: WELL APPROP. X
DRILLER ___ OWNER ___ USGS ___ SCS ___
OTHER: ____

HAS WELL LOCATION BEEN VERIFIED YES
BY WHOM HERMAN MOORE AGENCY MBMG
DATE VERIFIED 5/26/82

		DATE
MEAS. POINT ABOVE LSD	____ ft.	____
TOTAL DEPTH BELOW LSD	____ ft.	____
PUMPING LEVEL BELOW LSD	____ ft.	____
SWL* BELOW LSD	____ ft.	____
YIELD IN GPM	____	____
WATER TEMP. °C	____	____
SPECIFIC COND. at 25°C	____	____

MBMG FILE NUMBER ____
DNR FILE NUMBER ____
WELL FORM NUMBER ____
MBMG WQ LAB. NUMBER ____
SYS 2000 NUMBER ____
OTHER: ____

REMARKS: ____

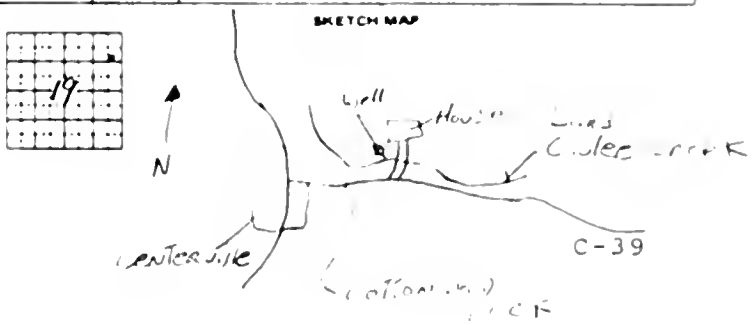
*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	10	TOP SOIL
10	30	BROKEN SANDSTONE & CLAY
30	35	BROKEN SANDSTONE, GRAVEL WATER
35	80	GRAY SANDY SILT
80	100	BROWN SANDY SILT
100	107	GRAY BROKEN LIMESTONE
TOP	MUD	??

SKETCH MAP



MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY CASCADE T. 19 N R. 5 E W SEC. 19 TRACT ABAB

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN SUBDIVISION BLOCK LOT

OWNER'S NAME GEORGE Heal WELL 2 ADDRESS

PHONE NUMBER YEAR

ALT. LAND SURF. AT WELL MSL 3575 ft.
TOTAL DEPTH BELOW LSD 410 ft.
PUMPING LEVEL BELOW LSD ft.
STATIC WATER LEVEL* BELOW LSD 70' ft.
YIELD IN GALLONS PER MIN. 7
HOW TESTED TIME (HR.)
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O Limestone MADISON

CASING DIA. 6 in. FROM ft. TO ft.
in. FROM ft. TO ft.
CASING TYPE Steel
PERFORATED INTERVAL ft. TO ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC.
PUMP SIZE (HP.) TYPE Sub.
DATE WELL COMPLETED
HOW DRILLED
BY WHOM LIC.
WELL USE Domestic 4 Houses
SOURCE OF INFO: WELL APPROP.
DRILLER OWNER X USGS SCS
OTHER:

HAS WELL LOCATION BEEN VERIFIED Yes
BY WHOM HERMAN MOORE AGENCY MBMG
DATE VERIFIED 6/02/82

		DATE
MEAS. POINT ABOVE LSD	ft.	
TOTAL DEPTH BELOW LSD	ft.	
PUMPING LEVEL BELOW LSD	ft.	
SWL* BELOW LSD	ft.	
YIELD IN GPM		
WATER TEMP. °C	9.8°	6/02/82
SPECIFIC COND. at 25°C	1284	6/02/82

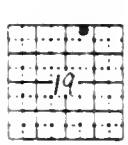
MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER:

REMARKS: Well serves four houses and water is stored in a 4500-gal. holding tank - because well will not pump dry since well runs

*F = FLOWING DRILLED AT CENTERVILLE

MBMG Form 182 (9/79) SENIOR CITIZENS BUILDING

LITHOLOGIC LOG		
INTERVAL (FT.)		DESCRIPTION
FROM	TO	



SKETCH MAP

C-40

MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY CASCADE T. 19 (N) or S R. 5 (E) or W SEC. 19 TRACT CAAD-1

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN SUBDIVISION BLOCK LOT

OWNER'S NAME Ronald Guisti ADDRESS Box 93 SAND COULEE

PHONE NUMBER YEAR

ALT. LAND SURF. AT WELL MSL 3487 ft.
TOTAL DEPTH BELOW LSD 238 ft.
PUMPING LEVEL BELOW LSD 230 ft.
STATIC WATER LEVEL* BELOW LSD 160 ft.
YIELD IN GALLONS PER MIN. 25
HOW TESTED PUMP TIME (HR.) 2
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O LIMESTONE MADISON

CASING DIA. 6 5/8 in. FROM 0 ft. TO 52 ft.
in. FROM ft. TO ft.
CASING TYPE Steel
PERFORATED INTERVAL ft. TO ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC.
PUMP SIZE (HP.) TYPE
DATE WELL COMPLETED 11/26/79
HOW DRILLED CABLE
BY WHOM PAT BYRNE LIC. 318
WELL USE DOMESTIC
SOURCE OF INFO: WELL APPROP. X
DRILLER OWNER USGS SCS
OTHER:

HAS WELL LOCATION BEEN VERIFIED Yes
BY WHOM HERMAN MOOR AGENCY MBMG
DATE VERIFIED 6/20/82

			DATE
MEAS. POINT ABOVE LSD		ft.	
TOTAL DEPTH BELOW LSD		ft.	
PUMPING LEVEL BELOW LSD		ft.	6/20/82
SWL* BELOW LSD		ft.	
YIELD IN GPM	10		6/20/82
WATER TEMP. °C	13.5°		6/20/82
SPECIFIC COND. at 25°C	914		6/20/82

MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER:

REMARKS: Blowing well

*F = FLOWING
MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	10	FILL
10	16	SANDY LOOM
16	23	BROWN SAND STONE
23	45	Yellow SAND STONE
45	50	LIME W/CHERT AND SANDSTONE
50	80	Yellow LIMESTONE
80	175	BROWN LIMESTONE
175	238	LIGHT CROWN LIMESTONE
		WATER AT 225-238

SKETCH MAP

C-41

MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY CASCADE T. 19 (N) S R. 5 (E) W SEC. 19 TRACT CAAD-2

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN SUBDIVISION BLOCK LOT

OWNER'S NAME BRIAN GUISTI ADDRESS STAR RT. STOCKETT

PHONE NUMBER YEAR

ALT. LAND SURF. AT WELL MSL 3510 ft.
TOTAL DEPTH BELOW LSD 290 ft.
PUMPING LEVEL BELOW LSD 285 ft.
STATIC WATER LEVEL* BELOW LSD 205 ft.
YIELD IN GALLONS PER MIN. 15
HOW TESTED BAILER TIME (HR.) 2
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O LIMESTONE MADISON

CASING DIA. 6⅝ in. FROM 0 ft. TO 71 ft.
___ in. FROM ___ ft. TO ___ ft.
CASING TYPE STEEL
PERFORATED INTERVAL ___ ft. TO ___ ft.
___ ft. TO ___ ft.
___ ft. TO ___ ft.
PERFORATION DESC.
PUMP SIZE (HP.) 12 TYPE
DATE WELL COMPLETED 8/20/78
HOW DRILLED CABLE
BY WHOM PAT BYRNE LIC. 135
WELL USE DOMESTIC
SOURCE OF INFO: WELL APPROP. X
DRILLER ___ OWNER X USGS ___ SCS ___
OTHER:

HAS WELL LOCATION BEEN VERIFIED YES
BY WHOM HERMAN MOORE AGENCY MBMG
DATE VERIFIED 6/02/82

MEAS. POINT ABOVE LSD	-4.50 ft.	DATE
TOTAL DEPTH BELOW LSD	___ ft.	___
PUMPING LEVEL BELOW LSD	___ ft.	___
SWL* BELOW LSD	196.9 ft.	6/20/82
YIELD IN GPM	13.8	6/20/82
WATER TEMP. °C	12.0	6/02/82
SPECIFIC COND. at 25°C	826	6/20/82

MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER:

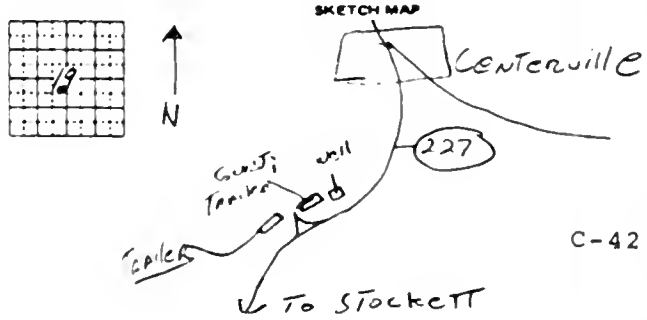
REMARKS:

*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	4	BROKEN ROCK
4	27	GRAY SHALE
27	55	HARD SHALE ROCK H_2O AT 55'
55	63	BLACK SAND STONE W/ GYRITE
63	72	GRAY SAND ROCK
72	75	RUSTY BROWN SAND STONE
75	85	BROWN SAND STONE
85	180	GRAY LIMESTONE
180	290	BROWN LIMESTONE H_2O AT 285'



C-42

M9

MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY CASCADE T. 19 ☐ or ☐ R. 5 ☐ or ☐ W SEC. 20 TRACT BBCD

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN SUBDIVISION BLOCK LOT

OWNER'S NAME DIANE KNOX ADDRESS Box 73 Sand Coulee MT.

PHONE NUMBER YEAR

ALT. LAND SURF. AT WELL MSL 3490 ft.
TOTAL DEPTH BELOW LSD 258 ft.
PUMPING LEVEL BELOW LSD 258 ft.
STATIC WATER LEVEL* BELOW LSD 150 ft.
YIELD IN GALLONS PER MIN. 10
HOW TESTED BOWER TIME (HR.) ½
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O LIMESTONE MADISON

CASING DIA. 6¼ in. FROM 0 ft. TO 20 ft.
6¼ in. FROM 20 ft. TO 80 ft.
CASING TYPE STEEL 0-20 - PLASTIC 20-80
PERFORATED INTERVAL ft. TO ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC.
PUMP SIZE (HP.) TYPE
DATE WELL COMPLETED 11/14/79
HOW DRILLED FORWARD ROTARY
BY WHOM SURE WATER DRILLERS LIC. 178
WELL USE DOMESTIC + STOCK
SOURCE OF INFO: WELL APPROP. X
DRILLER ___ OWNER ___ USGS ___ SCS ___
OTHER:

HAS WELL LOCATION BEEN VERIFIED YES
BY WHOM TERMAN MOORE AGENCY MBMG
DATE VERIFIED 6/02/82

			DATE
MEAS. POINT ABOVE LSD	1	ft.	
TOTAL DEPTH BELOW LSD		ft.	
PUMPING LEVEL BELOW LSD		ft.	
SWL* BELOW LSD	81.7	ft.	6/02/82
YIELD IN GPM			
WATER TEMP. °C	13.2°		6/02/82
SPECIFIC COND. at 25°C	2911		6/02/82

MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER:

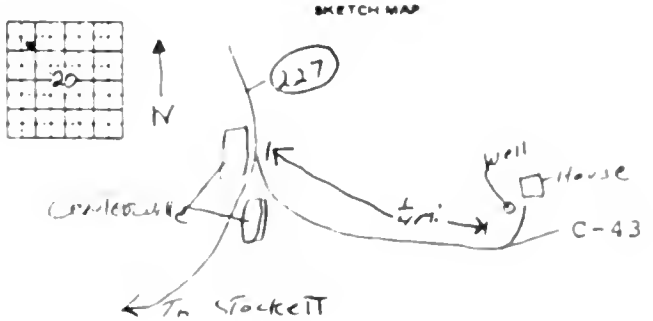
REMARKS: WATER IS VERY HARD

*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG		
INTERVAL (FT.) FROM	TO	DESCRIPTION
0	10	Top Soil
10	40	SHALE
40	258	Lime Rock

SKETCH MAP



J2

MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY CASCADE T. 20 N or S R. 4 E or W SEC. 36 TRACT BAAC

LAT. ° ' " N. LONG. ° ' " W. UTM ____ N ____ E ____

TOWN ____ SUBDIVISION ____ BLOCK ____ LOT ____

OWNER'S NAME ROBERT VINING ADDRESS R. ROUTE BOX 2160 G.F.

PHONE NUMBER 736-5260 YEAR ____

ALT. LAND SURF. AT WELL MSL 3390 ft.
TOTAL DEPTH BELOW LSD 100 ft.
PUMPING LEVEL BELOW LSD 55 ft.
STATIC WATER LEVEL* BELOW LSD 20 ft.
YIELD IN GALLONS PER MIN. 60
HOW TESTED BAILER TIME (HR.) 1
IF F, SHUT-IN PRESS. IN PSI ____
GEOLOGICAL SOURCE OF H_2O Jurassic Undiff.

CASING DIA. 6 in. FROM 0 ft. TO 60 ft.
____ in. FROM ____ ft. TO ____ ft.
CASING TYPE ____
PERFORATED INTERVAL ____ ft. TO ____ ft.
____ ft. TO ____ ft.
____ ft. TO ____ ft.
PERFORATION DESC. ____
PUMP SIZE (HP.) ____ TYPE ____
DATE WELL COMPLETED 11-9-81
HOW DRILLED ____
BY WHOM PAT BYRNE LIC. 125
WELL USE DOMESTIC
SOURCE OF INFO: WELL APPROP. X
DRILLER ___ OWNER " USGS ___ SCS ___
OTHER: ____

HAS WELL LOCATION BEEN VERIFIED Yes
BY WHOM HERMAN MOOGE AGENCY MBMG
DATE VERIFIED 5/27/82

		DATE
MEAS. POINT ABOVE LSD	____ ft.	
TOTAL DEPTH BELOW LSD	____ ft.	____
PUMPING LEVEL BELOW LSD	____ ft.	____
SWL* BELOW LSD	24.73 ft.	5/27/82
YIELD IN GPM	____	5/27/82
WATER TEMP. °C	9.5	5/27/82
SPECIFIC COND. at 25°C	1336	5/27/82

MBMG FILE NUMBER ____
DNR FILE NUMBER ____
WELL FORM NUMBER ____
MBMG WQ LAB. NUMBER ____
SYS 2000 NUMBER ____
OTHER: ____

REMARKS: OLD well 160' went CAD DUE TO FE

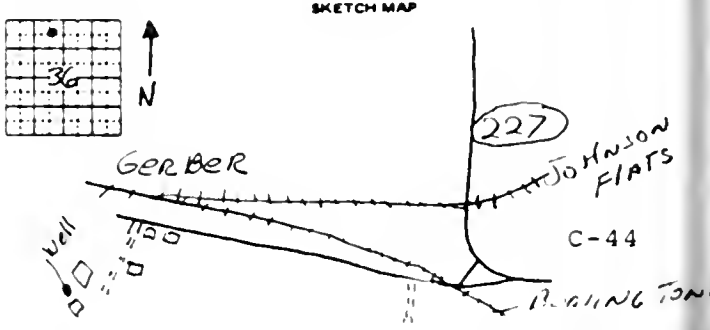
*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG

INTERVAL (FT.) FROM	TO	DESCRIPTION
0	5	TOP SOIL
5	19	YELLOW [illegible]
19	32	[illegible]
32	44	PINK SHALE
44	50	[illegible]
50	57	[illegible]
57	75	[illegible]
75	79	[illegible] SHALE
79	92	[illegible] SANDSTONE
92	97	HARD BLACK SHALE
97	100	[illegible] SHALE

SKETCH MAP



.M10

MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY CASCADE T. 20 (N) or S R. 5 (E) or W SEC. 31 TRACT CDAA

LAT. ° ' " N. LONG. ° ' " W. UTM ____ N ____ E ____

TOWN ____ SUBDIVISION ____ BLOCK ____ LOT ____

OWNER'S NAME GENE (OTTO) JOHNSON ADDRESS STAR RT SUN RIVER MT

PHONE NUMBER ____ YEAR ____

ALT. LAND SURF. AT WELL MSL 3402 ft.
TOTAL DEPTH BELOW LSD 125 ft.
PUMPING LEVEL BELOW LSD ____ ft.
STATIC WATER LEVEL* BELOW LSD 100 ft.
YIELD IN GALLONS PER MIN. 12
HOW TESTED ____ TIME (HR.) ____
IF F, SHUT-IN PRESS. IN PSI ____
GEOLOGICAL SOURCE OF H_2O LIMESTONE MADISON

CASING DIA. 6 in. FROM 0 ft. TO 100 ft.
____ in. FROM ____ ft. TO ____ ft.
CASING TYPE STEEL
PERFORATED INTERVAL ____ ft. TO ____ ft.
____ ft. TO ____ ft.
____ ft. TO ____ ft.
PERFORATION DESC. ____
PUMP SIZE (HP.) ____ TYPE ____
DATE WELL COMPLETED 12/-
HOW DRILLED ____
BY WHOM ____ LIC. ____
WELL USE DOMESTIC + STOCK
SOURCE OF INFO: WELL APPROP. X
DRILLER ___ OWNER X USGS ___ SCS ___
OTHER: ____

HAS WELL LOCATION BEEN VERIFIED Yes
BY WHOM HERMAN R MOORE AGENCY MBMG
DATE VERIFIED 5/28/82

			DATE
MEAS. POINT ABOVE LSD		ft.	
TOTAL DEPTH BELOW LSD		ft.	
PUMPING LEVEL BELOW LSD		ft.	
SWL* BELOW LSD	65.81	ft.	5/28/82
YIELD IN GPM	5.4		6/16/82
WATER TEMP. °C	9.0		5/28/82
SPECIFIC COND. at 25°C	1698		6/18/82

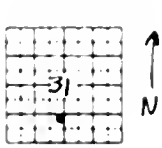
MBMG FILE NUMBER ____
DNR FILE NUMBER ____
WELL FORM NUMBER ____
MBMG WQ LAB. NUMBER ____
SYS 2000 NUMBER ____
OTHER: ____

REMARKS: ____

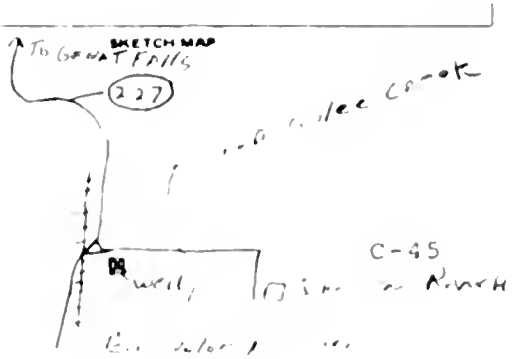
*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG		
INTERVAL (FT.) FROM	TO	DESCRIPTION



SKETCH MAP



M11

MONTANA BUREAU OF MINES AND GEOLOGY
WELL-DATA SHEET

COUNTY CASCADE T. 20 N or S R. 5 E or W SEC. 31 TRACT DDDB

LAT. ° ' " N. LONG. ° ' " W. UTM N E

TOWN SUBDIVISION BLOCK LOT

OWNER'S NAME Gene (OTTO) Johnson well ADDRESS STAR RT. Sand Coulee

PHONE NUMBER YEAR

ALT. LAND SURF. AT WELL MSL 3418 ft.
TOTAL DEPTH BELOW LSD 200 ft.
PUMPING LEVEL BELOW LSD UNUSED ft.
STATIC WATER LEVEL* BELOW LSD ft.
YIELD IN GALLONS PER MIN.
HOW TESTED TIME (HR.)
IF F, SHUT-IN PRESS. IN PSI
GEOLOGICAL SOURCE OF H_2O LIMESTONE MADISON

CASING DIA. 6 in. FROM ft. TO ft.
in. FROM ft. TO ft.
CASING TYPE Steel
PERFORATED INTERVAL ft. TO ft.
ft. TO ft.
ft. TO ft.
PERFORATION DESC.
PUMP SIZE (HP.) TYPE
DATE WELL COMPLETED
HOW DRILLED
BY WHOM LIC.
WELL USE UNUSED
SOURCE OF INFO: WELL APPROP.
DRILLER ___ OWNER X USGS ___ SCS ___
OTHER:

HAS WELL LOCATION BEEN VERIFIED Yes
BY WHOM Herman Moore AGENCY MB.MG
DATE VERIFIED 5/28/82
MEAS. POINT ABOVE LSD ft. DATE
TOTAL DEPTH BELOW LSD ft.
PUMPING LEVEL BELOW LSD ft.
SWL* BELOW LSD 72.15 ft. 5/28/82
YIELD IN GPM
WATER TEMP. °C
SPECIFIC COND. at 25°C
MBMG FILE NUMBER
DNR FILE NUMBER
WELL FORM NUMBER
MBMG WQ LAB. NUMBER
SYS 2000 NUMBER
OTHER:

REMARKS: WATER WENT BAD

*F = FLOWING

MBMG Form 182 (9/79)

LITHOLOGIC LOG		
INTERVAL (FT.)		DESCRIPTION
FROM	TO	

SKETCH MAP

C-2

GROUNDWATER QUALITY LABORATORY ANALYSES

MONTANA BUREAU OF MINES AND GEOLOGY
BUTTE,MONTANA 59701 (406)496 4101

WATER QUALITY ANALYSIS
LAB NO. 8200490

STATE	MONTANA	COUNTY	CASCADE
LATITUDE LONGITUDE	47D23'01"N 111D08'52"W	SITE LOCATION	19N 5E 12*CAAD 01
UTM COORDINATES	Z N E	MBMG SITE	
TOPOGRAPHIC MAP	SOUTHEAST GREAT FALLS 7.1	STATION ID	472301111085201
GEOLOGIC SOURCE	330MDSN* *	SAMPLE SOURCE	WELL
DRAINAGE BASIN	BB	LAND SURFACE ALTITUDE	3480. FT 10
AGENCY & SAMPLER	MBMG*NRM	SUSTAINED YIELD	10.0 GPM
BOTTLE NUMBER	RGUISTI	YIELD MEAS METHOD	BUCKET/STOPWATCH
DATE SAMPLED	20 JUN 82	TOTAL DEPTH OF WELL	238. FT (R)
TIME SAMPLED	10:45 HOURS	SWL ABOVE( ) OR BELOW GS	150. FT (R)
LAB & ANALYST	MBMG*ENA	CASING DIAMETER	6 IN (M)
DATE ANALYZED	16-JUL-82	CASING TYPE	STEEL
SAMPLE HANDLING		COMPLETION TYPE	*
METHOD SAMPLED	PUMPED	PERFORATION INTERVAL	
WATER USE	DOMESTIC		

SAMPLING SITE RONALD GUISTI .5 MI SW OF CENTERVILLE
GEOLOGIC SOURCE MADISON GROUP OR LIMESTONE

	MG/L	MEQ/L		MG/L	MEQ/L
CALCIUM (CA)	113.	5.64	BICARBONATE (HCO3)	229.8	3.77
MAGNESIUM (MG)	38.4	3.16	CARBONATE (CO3)	.0	
SODIUM (NA)	13.1	0.57	CHLORIDE (CL)	2.8	0.08
POTASSIUM (K)	4.2	0.11	SULFATE (SO4)	312.	6.50
IRON (FE)	<.002		NITRATE (AS N)	5.62	0.41
MANGANESE (MN)	<.001		FLUORIDE (F)	.53	0.03
SILICA (SIO2)	8.5		PHOSPHATE TOT (AS P)		
TOTAL CATIONS		9.48	TOTAL ANIONS		10.78

STANDARD DEVIATION OF ANION-CATION BALANCE (SIGMA) 5.13

LABORATORY PH	7.52	TOTAL HARDNESS AS CACO3	440.22
FIELD WATER TEMPERATURE	14.5 C	TOTAL ALKALINITY AS CACO3	188.48
CALCULATED DISSOLVED SOLIDS	611.42	SODIUM ADSORPTION RATIO	0.27
SUM OF DISS. CONSTITUENT	728.02	RYZNAR STABILITY INDEX	6.82
LAB SPEC.COND.(MICROMHOS/CM)	897.8	LANGLIER SATURATION INDEX	0.35

PARAMETER	VALUE	PARAMETER	VALUE
TEMPERATURE, AIR (C)	76. F	CNDUCTVY,FIELD MICROMHOS	914.
FIELD PH	7.53	ALKALINITY,FLD(AS CACO3)	185.4
ALUMINUM, DISS (MG/L-AL)	<.003	NICKEL,DISS (MG/L AS NI)	<.01
SILVER,DISS (MG/L AS AG)	<.002	LEAD,DISS (MG/L AS PB)	.05
BORON ,DISS (MG/L AS B)	<.02	STRONTIUM,DISS (MG/L-SR)	.29
CADMIUM,DISS(MG/L AS CD)	.002	TITANIUM DIS(MG/L AS TI)	.003
CHROMIUM, DISS (MG/L-CR)	.008	VANADIUM,DISS(MG/L AS V)	.007
COPPER,DISS (MG/L AS CU)	.013	ZINC,DISS (MG/L AS ZN)	.19
LITHIUM,DISS(MG/L AS LI)	.014	ZIRCONIUM DIS(MG/L AS ZR	.011
MOLYBDENUM,DISS(MG/L-MO)	<.02		

REMARKS: WATER CLEAR*TASTE AND SMELL OK*LIGHT BROWN STAIN ON FILTER
OWNERS ADDRESS BOX 23 SAND COULEE BLOWING WELL
LAB: FU CA 130, MG 44.5 GIVES 10.8 MEQ CATIONS FOR -.183 SIGMA

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L = MILLIEQUIVELENTS PER LITER. FT = FEET, MI = METERS. (M) = MEASURED, (E) = ESTIMATED, (R) = REPORTED. TR = TOTAL RECOVERABLE. TOT = TOTAL.

	QW	WA	S2	WI	OW	PW	AT	OTHER
OTHER AVAILABLE DATA		Y						
OTHER FILE NUMBERS:								

PROJECT: COST:
LAST EDIT DATE: 29-JUL-82 BY: IS *RCS
PROCESSING PROGRAM: F1730P V2 (11/3/81) PRINTED: 27-MAY-83

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
59.5	33.3	6.0	1.1	0.8	62.8	36.4	0.0

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: 8200490

MONTANA BUREAU OF MINES AND GEOLOGY
BUTTE,MONTANA 59701 (406)496-4101

WATER QUALITY ANALYSIS
LAB NO. 8200491

STATE	MONTANA	COUNTY	CASCADE
LATITUDE-LONGITUDE	47D19'09"N 111D09'14"W	SITE LOCATION	18N 5E 18*BBBA
UTM COORDINATES	Z N E	MBMG SITE	
TOPOGRAPHIC MAP	STOCKETT 7 1/2'	STATION ID	471909111091401
GEOLOGIC SOURCE	* * *	SAMPLE SOURCE	SPRING
DRAINAGE BASIN	BB	LAND SURFACE ALTITUDE	3875. FT < 10
AGENCY & SAMPLER	MBMG*WJD	SUSTAINED YIELD	
BOTTLE NUMBER	SHIRLEY	YIELD MEAS METHOD	
DATE SAMPLED	22-JUN-82	TOTAL DEPTH OF WELL	
TIME SAMPLED	12:15 HOURS	SWL ABOVE(-) OR BELOW GS	FLOWING
LAB & ANALYST	MBMG*FNA	CASING DIAMETER	
DATE ANALYZED	16-JUL-82	CASING TYPE	
SAMPLE HANDLING		COMPLETION TYPE	*
METHOD SAMPLED		PERFORATION INTERVAL	
WATER USE	DOMESTIC		

SAMPLING SITE SHIRLEY, WILLIAM*2.5 MI UP COTTONWOOD CK
GEOLOGIC SOURCE

	MG/L	MEQ/L		MG/L	MEQ/L
CALCIUM (CA)	62.1	3.10	BICARBONATE (HCO3)	300.	4.92
MAGNESIUM (MG)	32.5	2.67	CARBONATE (CO3)	.0	
SODIUM (NA)	10.1	0.44	CHLORIDE (CL)	3.8	0.11
POTASSIUM (K)	2.8	0.07	SULFATE (SO4)	27.6	0.57
IRON (FE)	<.002		NITRATE (AS N)	10.1	0.72
MANGANESE (MN)	<.001		FLUORIDE (F)	.36	0.02
SILICA (SIO2)	9.9		PHOSPHATE TOT (AS P)		
TOTAL CATIONS		6.28	TOTAL ANIONS		6.34

STANDARD DEVIATION OF ANION-CATION BALANCE (SIGMA) 0.20

LABORATORY PH	7.55	TOTAL HARDNESS AS CACO3	288.83
FIELD WATER TEMPERATURE	14.2 C	TOTAL ALKALINITY AS CACO3	246.05
CALCULATED DISSOLVED SOLIDS	307.04	SODIUM ADSORPTION RATIO	0.26
SUM OF DISS. CONSTITUENT	459.26	RYZNAR STABILITY INDEX	7.08
LAB SPEC.COND.(MICROMHOS/CM)	569.6	LANGLIER SATURATION INDEX	0.23

PARAMETER	VALUE	PARAMETER	VALUE
TEMPERATURE, AIR (C)	71. F	CNDUCTVY,FIELD MICROMHOS	576.
FIELD PH	8.75	ALKALINITY,FLD(AS CACO3)	250.
ALUMINUM, DISS (MG/L-AL)	<.03	NICKEL,DISS (MG/L AS NI)	<.01
SILVER,DISS (MG/L AS AG)	<.002	LEAD,DISS (MG/L AS PB)	<.04
BORON ,DISS (MG/L AS B)	<.02	STRONTIUM,DISS (MG/L-SR)	.27
CADMIUM,DISS(MG/L AS CD)	<.002	TITANIUM DIS(MG/L AS TI)	.005
CHROMIUM, DISS (MG/L-CR)	<.002	VANADIUM,DISS(MG/L AS V)	<.001
COPPER,DISS (MG/L AS CU)	.006	ZINC,DISS (MG/L AS ZN)	.047
LITHIUM,DISS(MG/L AS LI)	.007	ZIRCONIUM DIS(MG/L AS ZR	<.003
MOLYBDENUM,DISS(MG/L-MO)	<.02		

REMARKS: FROM STOCKETT* FILTER CLEAN* WATER CLEAR
WILLIAM SHIRLEY* RT 36 STOCKETT MT, 59480
ARTESIAN SPRING

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L = MILLIEQUIVELENTS PER LITER, FT = FEET, MT = METERS, (M) = MEASURED, (E) = ESTIMATED, (R) = REPORTED, TR = TOTAL RECOVERABLE, TOT = TOTAL.

QW WA S2 WI OW PW AT OTHER

OTHER AVAILABLE DATA
OTHER FILE NUMBERS:

PROJECT:		COST:	
LAST EDIT DATE:	29-JUL-82	BY:	TP *BCS
PROCESSING PROGRAM:	F1730P V2 (11/3/81)	PRINTED:	27-MAY-83

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
49.3	42.5	7.0	1.1	1.9	10.3	87.8	0.0

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: 8200491

MONTANA BUREAU OF MINES AND GEOLOGY
BUTTE, MONTANA 59701 (406)496 4101

WATER QUALITY ANALYSIS
LAB NO. 8200492

STATE	MONTANA	COUNTY	CASCADE
LATITUDE-LONGITUDE	47D23'50"N 110D10'35"W	SITE LOCATION	19N 04E 14 DADA
UTM COORDINATES	? N E	MRMG SITE	
TOPOGRAPHIC MAP	SOUTHEAST GREAT FALLS 7 1	STATION ID	472350110103501
GEOLOGIC SOURCE	217KOTN* *	SAMPLE SOURCE	WELL
DRAINAGE BASIN	BR	LAND SURFACE ALTITUDE	3680. FT T0
AGENCY & SAMPLER	MRMG*WJD	SUSTAINED YIELD	
BOTTLE NUMBER	SCWU*W2	YIELD MEAS METHOD	
DATE SAMPLED	19 JUN 82	TOTAL DEPTH OF WELL	210. (R)
TIME SAMPLED	14:10 HOURS	SWL ABOVE(-) OR BELOW GS	150. FT (R)
LAB & ANALYST	MRMG*ENA	CASING DIAMETER	6 IN (R)
DATE ANALYZED	07-JUL-82	CASING TYPE	STEEL
SAMPLE HANDLING		COMPLETION TYPE	01*
METHOD SAMPLED	PUMPED	PERFORATION INTERVAL	
WATER USE	PUBLIC SUPPLY		

SAMPLING SITE SAND COULEE WTR USERS BENCH W ABV SAND COU
GEOLOGIC SOURCE KOOTENAI FORMATION

	MG/L	MEQ/L		MG/L	MEQ/L
CALCIUM (CA)	51.7	2.58	BICARBONATE (HCO3)	444.	7.28
MAGNESIUM (MG)	69.9	5.75	CARBONATE (CO3)	0.	
SODIUM (NA)	17.2	0.75	CHLORIDE (CL)	12.3	0.35
POTASSIUM (K)	2.9	0.07	SULFATE (SO4)	71.	1.48
IRON (FE)	.011	0.00	NITRATE (AS N)	1.22	0.09
MANGANESE (MN)	.024	0.00	FLUORIDE (F)	1.1	0.06
SILICA (SIO2)	7.5		PHOSPHATE TOT (AS P)		
TOTAL CATIONS		9.15	TOTAL ANIONS		9.25

STANDARD DEVIATION OF ANION-CATION BALANCE (SIGMA) 0.39

LABORATORY PH	7.69	TOTAL HARDNESS AS CACO3	416.80
FIELD WATER TEMPERATURE	15. C	TOTAL ALKALINITY AS CACO3	364.16
CALCULATED DISSOLVED SOLIDS	453.57	SODIUM ADSORPTION RATIO	0.37
SUM OF DISS. CONSTITUENT	678.86	RYZNAR STABILITY INDEX	6.76
LAB SPEC.COND.(MICROMHOS/CM)	789.2	LANGLIER SATURATION INDEX	0.46

PARAMETER	VALUE	PARAMETER	VALUE
TEMPERATURE, AIR (C)	86. F	CNDUCTVY,FIELD MICROMHOS	833.
FIELD PH	7.48	ALKALINITY,FLD(AS CACO3)	738.
ALUMINUM, DISS (MG/L-AL)	<.03	NICKEL,DISS (MG/L AS NI)	<.01
SILVER,DISS (MG/L AS AG)	<.002	LEAD,DISS (MG/L AS PB)	<.04
BORON ,DISS (MG/L AS B)	.05	STRONTIUM,DISS (MG/L-SR)	.52
CADMIUM,DISS(MG/L AS CD)	<.002	TITANIUM DIS(MG/L AS TI)	<.001
CHROMIUM, DISS (MG/L-CR)	<.002	VANADIUM,DISS(MG/L AS V)	<.001
COPPER,DISS (MG/L AS CU)	<.002	ZINC,DISS (MG/L AS ZN)	.25
LITHIUM,DISS(MG/L AS LI)	.042	ZIRCONIUM DIS(MG/L AS ZR	<.003
MOLYBDENUM,DISS(MG/L-MO)	.06		

REMARKS: FILTER BROWN SILT * WATER CLOUDY
JOHN G. MITTAL PRES.

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L = MILLIEQUIVELENTS PER LITER. FT = FEET, MT = METERS. (M) = MEASURED, (E) = ESTIMATED, (R) = REPORTED. TR = TOTAL RECOVERABLE. TOT = TOTAL.

	QW	WA	S2	W1	QW	PN	AT	OTHER
OTHER AVAILABLE DATA		Y						

OTHER FILE NUMBERS:

PROJECT:		COST:	
LAST EDIT DATE:	23-JUL-82	BY:	TP *CMT
PROCESSING PROGRAM:	F1730P V2 (11/3/81)	PRINTED:	27-MAY-83

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
28.2	62.8	8.2	0.8	3.8	16.2	79.9	0.0

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: 8200492

MONTANA BUREAU OF MINES AND GEOLOGY
BUTTE,MONTANA 59701 (406)496-4101

WATER QUALITY ANALYSIS
LAB NO. 8200493

STATE	MONTANA	COUNTY	CASCADE
LATITUDE-LONGITUDE	47D24'14"N 110D09'17"W	SITE LOCATION	19N 4E 13 AADD
UTM COORDINATES	Z N E	MBMG SITE	
TOPOGRAPHIC MAP	SOUTHEAST GREAT FALLS 7.1	STATION ID	472414110091701
GEOLOGIC SOURCE	330MDSN* * *	SAMPLE SOURCE	WELL
DRAINAGE BASIN	BB	LAND SURFACE ALTITUDE	3440. FT < 10
AGENCY & SAMPLER	MBMG*MBM	SUSTAINED YIELD	10.0 GPM
BOTTLE NUMBER	CHENSTM	YIELD MEAS METHOD	BUCKET/STOPWATCH
DATE SAMPLED	22-JUN-82	TOTAL DEPTH OF WELL	185. FT (R)
TIME SAMPLED	10:00 HOURS	SWL ABOVE(-) OR BELOW GS	121. FT (R)
LAB & ANALYST	MBMG*FNA	CASING DIAMETER	6 IN (M)
DATE ANALYZED	07-JUL-82	CASING TYPE	STEEL
SAMPLE HANDLING		COMPLETION TYPE	*
METHOD SAMPLED	PUMPED	PERFORATION INTERVAL	
WATER USE	DOMESTIC		

SAMPLING SITE CHARLES ENTSMINGER*TOWN OF NUMBER SEVEN
GEOLOGIC SOURCE MADISON GROUP OR LIMESTONE

	MG/L	MEQ/L		MG/L	MEQ/L
CALCIUM (CA)	79.6	3.97	BICARBONATE (HCO3)	246.9	4.05
MAGNESIUM (MG)	28.7	2.36	CARBONATE (CO3)	.0	
SODIUM (NA)	11.4	0.50	CHLORIDE (CL)	4.0	0.11
POTASSIUM (K)	2.5	0.06	SULFATE (SO4)	132.	2.75
IRON (FE)	<.002		NITRATE (AS N)	.91	0.06
MANGANESE (MN)	<.001		FLUORIDE (F)	.44	0.02
SILICA (SIO2)	12.3		PHOSPHATE TOT (AS P)		
TOTAL CATIONS		6.89	TOTAL ANIONS		7.00

STANDARD DEVIATION OF ANION-CATION BALANCE (SIGMA) 0.49

LABORATORY PH	7.94	TOTAL HARDNESS AS CACO3	316.89
FIELD WATER TEMPERATURE	16. C	TOTAL ALKALINITY AS CACO3	202.50
CALCULATED DISSOLVED SOLIDS	393.48	SODIUM ADSORPTION RATIO	0.28
SUM OF DISS. CONSTITUENT	518.75	RYZNAR STABILITY INDEX	6.65
LAB SPEC.COND.(MICROMHOS/CM)	596.3	LANGLIER SATURATION INDEX	0.65

PARAMETER	VALUE	PARAMETER	VALUE
TEMPERATURE, AIR (C)	75. F	CNDUCTVY,FIELD MICROMHOS	620.
FIELD PH	7.27	ALKALINITY,FLD(AS CACO3)	412.4
ALUMINUM, DISS (MG/L-AL)	<.03	NICKEL,DISS (MG/L AS NI)	<.01
SILVER,DISS (MG/L AS AG)	<.003	LEAD,DISS (MG/L AS PB)	<.04
BORON ,DISS (MG/L AS B)	.24	STRONTIUM,DISS (MG/L-SR)	.72
CADMIUM,DISS(MG/L AS CD)	<.002	TITANIUM DIS(MG/L AS TI)	<.001
CHROMIUM, DISS (MG/L-CR)	<.002	VANADIUM,DISS(MG/L AS V)	<.001
COPPER,DISS (MG/L AS CU)	.004	ZINC,DISS (MG/L AS ZN)	.043
LITHIUM,DISS(MG/L AS LI)	.016	ZIRCONIUM DIS(MG/L AS ZR	<.003
MOLYBDENUM,DISS(MG/L-MO)	<.02		

REMARKS: WATER CLEAR *TASTE AND SMELL OF SILTY FILTER
OWNERS ADDRESS SAND COULEE

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L = MILLIEQUIVELENTS PER LITER, FT = FEET, MT = METERS. (M) = MEASURED, (E) = ESTIMATED, (R) = REPORTED. TR = TOTAL RECOVERABLE. TOT = TOTAL.

QW WA SS WI OW PW AT OTHER

OTHER AVAILABLE DATA
OTHER FILE NUMBERS:

PROJECT:		COST:	
LAST EDIT DATE:	23-JUL-82	BY:	TP *CMT
PROCESSING PROGRAM:	F1730P V2 (11/3/81)	PRINTED:	27-MAY-83

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
57.6	34.3	7.2	0.9	1.6	39.8	58.6	0.0

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: 8200493

MONTANA BUREAU OF MINES AND GEOLOGY
BUTTE, MONTANA 59701 (406)496 4101

WATER QUALITY ANALYSIS
LAB NO. 8200494

STATE MONTANA
LATITUDE-LONGITUDE 47D10'54"N 111D11'04"W
UTM COORDINATES Z N E
TOPOGRAPHIC MAP STOCKETT 7 1/2'
GEOLOGIC SOURCE 217XOTN* * *
DRAINAGE BASIN BB
AGENCY & SAMPLER MBMG*HRM
BOTTLE NUMBER R.YUREK
DATE SAMPLED 21-JUN 82
TIME SAMPLED 10:40 HOURS SWL
LAB & ANALYST MBMG*ENA
DATE ANALYZED 16-JUL-82
SAMPLE HANDLING
METHOD SAMPLED PUMPED
WATER USE DOMESTIC

COUNTY CASCADE
SITE LOCATION 18N 4E 14 ACBD
MBMG SITE
STATION ID 471054111110401
SAMPLE SOURCE SPRING
LAND SURFACE ALTITUDE 3880. FT 10
SUSTAINED YIELD 9.6 GPM
YIELD MEAS METHOD BUCKET/STOPWATCH
TOTAL DEPTH OF WELL
ABOVE(-) OR BELOW GS
CASING DIAMETER
CASING TYPE
COMPLETION TYPE *
PERFORATION INTERVAL

SAMPLING SITE RICK YUREK*.25 MI N OF GIFFEN SPRING
GEOLOGIC SOURCE KOOTENAI FORMATION

		MG/L	MEQ/L			MG/L	MEQ/L
CALCIUM	(CA)	49.3	2.46	BICARBONATE	(HCO3)	321.	5.26
MAGNESIUM	(MG)	38.9	3.20	CARBONATE	(CO3)	.0	
SODIUM	(NA)	8.4	0.37	CHLORIDE	(CL)	1.8	0.05
POTASSIUM	(K)	2.4	0.06	SULFATE	(SO4)	24.0	0.50
IRON	(FE)	.002		NITRATE	(AS N)	3.91	0.28
MANGANESE	(MN)	.001		FLUORIDE	(F)	.50	0.03
SILICA	(SIO2)	8.0		PHOSPHATE TOT	(AS P)		
TOTAL CATIONS			6.09	TOTAL ANIONS			6.12

STANDARD DEVIATION OF ANION-CATION BALANCE (SIGMA) 0.14

LABORATORY PH	7.61	TOTAL HARDNESS AS CACO3	283.21
FIELD WATER TEMPERATURE	10.5 C	TOTAL ALKALINITY AS CACO3	263.27
CALCULATED DISSOLVED SOLIDS	295.22	SODIUM ADSORPTION RATIO	0.22
SUM OF DISS. CONSTITUENT	458.09	RYZNAR STABILITY INDEX	7.16
LAB SPEC.COND.(MICROMHOS/CM)	537.4	LANGLIER SATURATION INDEX	0.22

PARAMETER	VALUE	PARAMETER	VALUE
TEMPERATURE, AIR (C)	75. F	CNDUCTVY,FIELD MICROMHOS	542.
FIELD PH	6.82	ALKALINITY,FLD(AS CACO3)	269.
ALUMINUM, DISS (MG/L-AL)	<.03	NICKEL,DISS (MG/L AS NI)	<.01
SILVER,DISS (MG/L AS AG)	<.002	LEAD,DISS (MG/L AS PB)	<.04
BORON ,DISS (MG/L AS B)	.07	STRONTIUM,DISS (MG/L-SR)	.30
CADMIUM,DISS(MG/L AS CD)	<.002	TITANIUM DIS(MG/L AS TI)	.001
CHROMIUM, DISS (MG/L-CR)	<.002	VANADIUM,DISS(MG/L AS V)	<.001
COPPER,DISS (MG/L AS CU)	<.002	ZINC,DISS (MG/L AS ZN)	.066
LITHIUM,DISS(MG/L AS LI)	.005	ZIRCONIUM DIS(MG/L AS ZR	.003
MOLYBDENUM,DISS(MG/L-MO)	.02		

REMARKS: WATER CLOUDY WITH BUBBLES*TASTE & SMELL OK*LIGHT BROWN STAIN ON FILTER
OWNERS ADDRESS EVANS ST STOCKETT

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L = MILLIEQUIVELENTS PER LITER, FT = FEET, MI = MILES, (M) = MEASURED, (E) = ESTIMATED, (R) = REPORTED, TR = TOTAL RECOVERABLE, TOT = TOTAL.

	QW	WA	S2	WI	OW	PW	AT	OTHER
OTHER AVAILABLE DATA								
OTHER FILE NUMBERS:								

PROJECT:
COST:
LAST EDIT DATE: 30-JUL-82 BY: IB *RCS
PROCESSING PROGRAM: F1730P V2 (11/3/81) PRINTED: 27-MAY-83

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
40.4	52.6	6.0	1.0	0.8	8.6	90.6	0.0

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: 8200494

```
MONTANA BUREAU OF MINES AND GEOLOGY          WATER QUALITY ANALYSIS
BUTTE,MONTANA  59701  (406)496-4101          LAB NO. 8200495

              STATE MONTANA                          COUNTY CASCADE
 LATITUDE-LONGITUDE 47D22'42"N 111D11'30"W    SITE LOCATION 19N  4E 23*CCDD
    UTM COORDINATES Z   N         E                    MBMG SITE
    TOPOGRAPHIC MAP SOUTHEAST GREAT FALLS 7.1      STATION ID 472242111113001
    GEOLOGIC SOURCE         *          *         *  SAMPLE SOURCE WELL
     DRAINAGE BASIN BB                      LAND SURFACE ALTITUDE  3680.  FT < 10
   AGENCY + SAMPLER MBMG*WJD                     SUSTAINED YIELD     8.6 GPM
      BOTTLE NUMBER LAROCRU                  YIELD MEAS METHOD BUCKET/STOPWATCH
       DATE SAMPLED                        TOTAL DEPTH OF WELL   100.  FT (E)
       TIME SAMPLED    :   HOURS     SWL ABOVE(-) OR BELOW GS     0.
     LAB + ANALYST MBMG*FNA                    CASING DIAMETER
      DATE ANALYZED 16-JUL-82                      CASING TYPE
    SAMPLE HANDLING                           COMPLETION TYPE    *
     METHOD SAMPLED PUMPED                  PERFORATION INTERVAL
         WATER USE DOMESTIC

      SAMPLING SITE LAROCRUE,H*TURNOFF 1.2MI SW OF SAND COULEE
    GEOLOGIC SOURCE

                      MG/L      MEQ/L                              MG/L      MEQ/L
  CALCIUM    (CA)     81.5       4.07 BICARBONATE    (HCO3)      407.       6.67
  MAGNESIUM  (MG)     47.7       3.92 CARBONATE      (CO3)         .0
  SODIUM     (NA)     14.7       0.64 CHLORIDE       (CL)         4.5       0.13
  POTASSIUM   (K)      2.9       0.07 SULFATE        (SO4)       65.5       1.36
  IRON       (FE)     <.002            NITRATE     (AS N)        5.32      0.42
  MANGANESE  (MN)      .12       0.00 FLUORIDE       (F)          .85       0.04
  SILICA    (SIO2)     8.5            PHOSPHATE TOT (AS P)

    TOTAL CATIONS                 8.71          TOTAL ANIONS                  8.63

    STANDARD DEVIATION OF ANION-CATION BALANCE   (SIGMA)       -0.35

            LABORATORY PH      7.51    TOTAL HARDNESS AS CACO3    399.84
     FIELD WATER TEMPERATURE           TOTAL ALKALINITY AS CACO3  333.81
 CALCULATED DISSOLVED SOLIDS   432.68   SODIUM ADSORPTION RATIO      0.32
    SUM OF DISS. CONSTITUENT   639.19    RYZNAR STABILITY INDEX      8.62
LAB SPEC.COND.(MICROMHOS/CM)   766.5   LANGLIER SATURATION INDEX     0.44

      PARAMETER                VALUE       PARAMETER                VALUE
TEMPERATURE, AIR (C)           63.      CNDUCTVY,FIELD MICROMHOS     755.
FIELD PH                       7.39     ALKALINITY,FLD(AS CACO3)     347.
ALUMINUM, DISS (MG/L-AL)       <.03     NICKEL,DISS (MG/L AS NI)      <.01
SILVER,DISS (MG/L AS AG)       <.002    LEAD,DISS  (MG/L AS PB)       <.04
BORON ,DISS (MG/L AS B)         .04     STRONTIUM,DISS (MG/L-SR)       .35
CADMIUM,DISS(MG/L AS CD)       <.002    TITANIUM DIS(MG/L AS TI)      <.001
CHROMIUM, DISS (MG/L-CR)       <.002    VANADIUM,DISS(MG/L AS V)      <.001
COPPER,DISS (MG/L AS CU)       <.002    ZINC,DISS  (MG/L AS ZN)        .013
LITHIUM,DISS(MG/L AS LI)        .023    ZIRCONIUM DIS(MG/L AS ZR      <.003
MOLYBDENUM,DISS(MG/L-MO)       <.02

REMARKS: FILTER CLEAN*WATER CLEAR
         HARVEY LAROCQUE*SAND COULEE, MT

EXPLANATION:  MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L =
MILLIEQUIVELENTS PER LITER,  FT = FEET, MT = METERS.  (M) = MEASURED, (E) =
ESTIMATED, (R) = REPORTED.  TR = TOTAL RECOVERABLE.  TOT = TOTAL.

                        QW  WA  SG  WI  OW  PW  AT      OTHER
OTHER AVAILABLE DATA
OTHER FILE NUMBERS:

          PROJECT:                                COST:
    LAST EDIT DATE:  30-JUL-82                      BY:  TP *BCS
PROCESSING PROGRAM:  F1730P V2 (11/3/81)     PRINTED:  27-MAY-83

                    PERCENT MEQ/L (FOR PIPER PLOT)
                      CA    MG    NA    K    CL   SO4 HCO3  CO3
                    46.7  45.1   7.3  0.9   1.6 16.7 81.7  0.0

NOTE:  IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER:  8200495
```

MONTANA BUREAU OF MINES AND GEOLOGY
BUTTE,MONTANA 59701 (406)496 4101

WATER QUALITY ANALYSIS
LAB NO. 0200496

STATE MONTANA
LATITUDE-LONGITUDE 47D23'02"N 111D08'52"W
UTM COORDINATES 7 N C
TOPOGRAPHIC MAP SOUTHEAST GREAT FALLS 7.1
GEOLOGIC SOURCE 330MBSN* *
DRAINAGE BASIN BR
AGENCY & SAMPLER MBMG*URM
BOTTLE NUMBER BRIANGU
DATE SAMPLED 20-JUN-82
TIME SAMPLED 18:45 HOURS
LAB & ANALYST MBMG*ENA
DATE ANALYZED 16-JUL-82
SAMPLE HANDLING
METHOD SAMPLED PUMPED
WATER USE DOMESTIC

COUNTY CASCADE
SITE LOCATION 19N 5E 19*CAAD 01
MBMG SITE
STATION ID 472302111085201
SAMPLE SOURCE WELL
LAND SURFACE ALTITUDE 3570. FT *0
SUSTAINED YIELD 13.0 GPM
YIELD MEAS METHOD BUCKET/STOPWATCH
TOTAL DEPTH OF WELL 220. FT (R)
SWL ABOVE(-) OR BELOW GS 196.90 FT (M)
CASING DIAMETER 6 IN
CASING TYPE STEEL
COMPLETION TYPE *
PERFORATION INTERVAL

SAMPLING SITE BRIAN GUIST .5 MI SW OF CENTERVILLE
GEOLOGIC SOURCE MADISON GROUP OR LIMESTONE

	MG/L	MEQ/L			MG/L	MEQ/L
CALCIUM (CA)	89.8	4.48	BICARBONATE	(HCO3)	215.7	3.54
MAGNESIUM (MG)	42.4	3.49	CARBONATE	(CO3)	.0	
SODIUM (NA)	10.2	0.44	CHLORIDE	(CL)	3.3	0.09
POTASSIUM (K)	3.6	0.09	SULFATE	(SO4)	228.	4.75
IRON (FE)	<.002		NITRATE	(AS N)	1.55	0.25
MANGANESE (MN)	<.001		FLUORIDE	(F)	.41	0.02
SILICA (SIO2)	12.4		PHOSPHATE TOT	(AS P)		
TOTAL CATIONS		8.51	TOTAL ANIONS			8.65

STANDARD DEVIATION OF ANION-CATION BALANCE (SIGMA) 0.63

LABORATORY PH	7.44	TOTAL HARDNESS AS CACO3	398.25
FIELD WATER TEMPERATURE	12. C	TOTAL ALKALINITY AS CACO3	176.91
CALCULATED DISSOLVED SOLIDS	499.92	SODIUM ADSORPTION RATIO	0.22
SUM OF DISS. CONSTITUENT	509.36	RYZNAR STABILITY INDEX	7.16
LAB SPEC.COND.(MICROMHOS/CM)	741.6	LANGLIER SATURATION INDEX	0.14

PARAMETER	VALUE	PARAMETER	VALUE
TEMPERATURE, AIR (C)	82. F	CNDUCTVY,FIELD MICROMHOS	826.
FIELD PH	7.00	ALKALINITY,FLD(AS CACO3)	182.8
ALUMINUM, DISS (MG/L-AL)	<.03	NICKEL,DISS (MG/L AS NI)	.01
SILVER,DISS (MG/L AS AG)	<.002	LEAD,DISS (MG/L AS PB)	<.04
BORON ,DISS (MG/L AS B)	.05	STRONTIUM,DISS (MG/L-SR)	.56
CADMIUM,DISS(MG/L AS CD)	<.002	TITANIUM DIS(MG/L AS TI)	.001
CHROMIUM, DISS (MG/L-CR)	<.001	VANADIUM,DISS(MG/L AS V)	.001
COPPER,DISS (MG/L AS CU)	.007	ZINC,DISS (MG/L AS ZN)	.24
LITHIUM,DISS(MG/L AS LI)	.013	ZIRCONIUM DIS(MG/L AS ZR	<.003
MOLYBDENUM,DISS(MG/L-MO)	<.02		

REMARKS: WATER CLEAR * TASTE & SMELL OK * CLEAN FILTER
OWNERS ADDRESS STAR RT STOCKETT

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L = MILLIEQUIVELENTS PER LITER, FT = FEET, MI = METERS, (M) = MEASURED, (F) = ESTIMATED, (R) = REPORTED, TR = TOTAL RECOVERABLE, TOT = TOTAL.

	QW	WA	S2	WI	OW	PW	AT	OTHER
OTHER AVAILABLE DATA		Y						

OTHER FILE NUMBERS:

PROJECT: COST:
LAST EDIT DATE: 30-JUL-82 BY: TP *RCG
PROCESSING PROGRAM: F1730P V2 (11/3/81) PRINTED: 27-MAY-83

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
52.7	41.0	5.2	1.1	1.1	56.7	42.2	0.0

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: 0200496

MONTANA BUREAU OF MINES AND GEOLOGY
BUTTE,MONTANA 59701 (406)496-4101

WATER QUALITY ANALYSIS
LAB NO. 8200497

STATE	MONTANA	COUNTY	CASCADE
LATITUDE-LONGITUDE	47D24'05"N 111D09'51"W	SITE LOCATION	19N 4E 13 ACCB
UTM COORDINATES	Z N E	MBMG SITE	
TOPOGRAPHIC MAP	SOUTHEAST GREAT FALLS 7.1	STATION ID	472405111095101
GEOLOGIC SOURCE	330MDSN* * *	SAMPLE SOURCE	WELL
DRAINAGE BASIN	BB	LAND SURFACE ALTITUDE	3460. FT < 10
AGENCY + SAMPLER	MBMG*WJB	SUSTAINED YIELD	3.2 GPM
BOTTLE NUMBER	GKAVULA	YIELD MEAS METHOD	BUCKET/STOPWATCH
DATE SAMPLED	21-JUN-82	TOTAL DEPTH OF WELL	328. FT (R)
TIME SAMPLED	10:40 HOURS	SWL ABOVE(-) OR BELOW GS	165. FT (R)
LAB + ANALYST	MBMG*FNA	CASING DIAMETER	8 IN
DATE ANALYZED	14-JUL-82	CASING TYPE	STEEL
SAMPLE HANDLING		COMPLETION TYPE	01*
METHOD SAMPLED	PUMPED	PERFORATION INTERVAL	
WATER USE	DOMESTIC		

SAMPLING SITE KAVULLA, GEORGE* SAND COULEE, MT
GEOLOGIC SOURCE MADISON GROUP OR LIMESTONE

	MG/L	MEQ/L		MG/L	MEQ/L
CALCIUM (CA)	111.	5.54	BICARBONATE (HCO3)	286.	4.69
MAGNESIUM (MG)	44.4	3.65	CARBONATE (CO3)	0	
SODIUM (NA)	13.6	0.59	CHLORIDE (CL)	9.7	0.27
POTASSIUM (K)	3.2	0.08	SULFATE (SO4)	236.	4.91
IRON (FE)	.007	0.00	NITRATE (AS N)	1.07	0.08
MANGANESE (MN)	.004	0.00	FLUORIDE (F)	.57	0.03
SILICA (SIO2)	12.3		PHOSPHATE TOT (AS P)		
TOTAL CATIONS		9.87	TOTAL ANIONS		9.98

STANDARD DEVIATION OF ANION-CATION BALANCE (SIGMA) 0.46

LABORATORY PH	7.15	TOTAL HARDNESS AS CACO3	459.92
FIELD WATER TEMPERATURE		TOTAL ALKALINITY AS CACO3	234.57
CALCULATED DISSOLVED SOLIDS	572.74	SODIUM ADSORPTION RATIO	0.28
SUM OF DISS. CONSTITUENT	717.85	RYZNAR STABILITY INDEX	7.02
LAB SPEC.COND.(MICROMHOS/CM)	846.1	LANGLIER SATURATION INDEX	0.07

PARAMETER	VALUE	PARAMETER	VALUE
TEMPERATURE, AIR (C)	75. F	CNDUCTVY,FIELD MICROMHOS	633.
FIELD PH	6.38	ALKALINITY,FLD(AS CACO3)	245.
ALUMINUM, DISS (MG/L-AL)	.03	NICKEL,DISS (MG/L AS NI)	<.01
SILVER,DISS (MG/L AS AG)	<.002	LEAD,DISS (MG/L AS PB)	.06
BORON ,DISS (MG/L AS B)	.07	STRONTIUM,DISS (MG/L-SR)	.86
CADMIUM,DISS(MG/L AS CD)	.003	TITANIUM DIS(MG/L AS TI)	<.001
CHROMIUM, DISS (MG/L-CR)	.004	VANADIUM,DISS(MG/L AS V)	.003
COPPER,DISS (MG/L AS CU)	.013	ZINC,DISS (MG/L AS ZN)	.73
LITHIUM,DISS(MG/L AS LI)	.020	ZIRCONIUM DIS(MG/L AS ZR	<.003
MOLYBDENUM,DISS(MG/L-MO)	<.02		

REMARKS: FILTER LIGHT BROWN*WATER CLOUDY
GEORGE KAVULLA*SAND COULEE, MT

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L = MILLIEQUIVELENTS PER LITER, FT = FEET, MT = METERS. (M) = MEASURED, (E) = ESTIMATED, (R) = REPORTED. TR = TOTAL RECOVERABLE. TOT = TOTAL.

	QW	WA	SO	WI	OW	FW	AT	OTHER
OTHER AVAILABLE DATA		Y						
OTHER FILE NUMBERS:								

PROJECT: COST:
LAST EDIT DATE: 30-JUL-82 BY: TP *BCS
PROCESSING PROGRAM: F1730P V2 (11/3/81) PRINTED: 27 MAY 83

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
56.1	37.0	6.0	0.8	2.8	49.8	47.5	0.0

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: 8200497

MONTANA BUREAU OF MINES AND GEOLOGY
BUTTE,MONTANA 59701 (406)496-4101

WATER QUALITY ANALYSIS
LAB NO. 8200490

STATE	MONTANA	COUNTY	CASCADE
LATITUDE-LONGITUDE	47D24'52"N 111D09'28"W	SITE LOCATION	19N 4E 12 BABA
UTM COORDINATES	Z N E	MBMG SITE	
TOPOGRAPHIC MAP	SOUTHEAST GREAT FALLS 7.1	STATION ID	472452111092001
GEOLOGIC SOURCE	220JKSC* *	SAMPLE SOURCE	WELL
DRAINAGE BASIN	BB	LAND SURFACE ALTITUDE	3430. (R) 10
AGENCY & SAMPLER	MBMG*WJD	SUSTAINED YIELD	7.0 GPM
DOTILE NUMBER	EVLYMAN	YIELD MEAS METHOD	BUCKET/STOPWATCH
DATE SAMPLED	21-JUN-82	TOTAL DEPTH OF WELL	131. FT (R)
TIME SAMPLED	09:15 HOURS	SWL ABOVE(-) OR BELOW GS	111 FT (R)
LAB & ANALYST	MBMG*ENA	CASING DIAMETER	7 IN
DATE ANALYZED	14-JUL-82	CASING TYPE	STEEL
SAMPLE HANDLING		COMPLETION TYPE	*
METHOD SAMPLED	PUMPED	PERFORATION INTERVAL	
WATER USE	DOMESTIC		

SAMPLING SITE LYMAN,F*1ST HOUSE ACROSS ROAD FROM TRACY
GEOLOGIC SOURCE JURASSIC UNDIFFERENTIATED

	MG/L	MEQ/L		MG/L	MEQ/L
CALCIUM (CA)	354.	17.66	BICARBONATE (HCO3)	507.	8.31
MAGNESIUM (MG)	115.	9.46	CARBONATE (CO3)	.0	
SODIUM (NA)	27.7	1.20	CHLORIDE (CL)	18.9	0.53
POTASSIUM (K)	5.5	0.14	SULFATE (SO4)	937.	19.51
IRON (FE)	.024	0.00	NITRATE (AS N)	3.67	0.26
MANGANESE (MN)	.004	0.00	FLUORIDE (F)	.18	0.01
SILICA (SIO2)	25.3		PHOSPHATE TOT (AS P)		
TOTAL CATIONS		28.47	TOTAL ANIONS		28.62

STANDARD DEVIATION OF ANION-CATION BALANCE (SIGMA) 0.22

LABORATORY PH	7.54	TOTAL HARDNESS AS CACO3	1357.28
FIELD WATER TEMPERATURE		TOTAL ALKALINITY AS CACO3	415.83
CALCULATED DISSOLVED SOLIDS	1737.03	SODIUM ABSORPTION RATIO	0.33
SUM OF DISS. CONSTITUENT	1994.28	RYZNAR STABILITY INDEX	5.12
LAB SPEC.COND.(MICROMHOS/CM)	2172.	LANGLIER SATURATION INDEX	1.21

PARAMETER	VALUE	PARAMETER	VALUE
TEMPERATURE, AIR (C)	72. F	CNDUCTVY,FIELD MICROMHOS	2240.
FIELD PH	7.15	ALKALINITY,FLD(AS CACO3)	426.
ALUMINUM, DISS (MG/L-AL)	.26	NICKEL,DISS (MG/L AS NI)	.03
SILVER,DISS (MG/L AS AG)	.049	LEAD,DISS (MG/L AS PB)	.07
BORON ,DISS (MG/L AS B)	.07	STRONTIUM,DISS (MG/L-SR)	1.08
CADMIUM,DISS(MG/L AS CD)	.015	TITANIUM DIS(MG/L AS TI)	.039
CHROMIUM, DISS (MG/L-CR)	.031	VANADIUM,DISS(MG/L AS V)	.048
COPPER,DISS (MG/L AS CU)	.074	ZINC,DISS (MG/L AS ZN)	.066
LITHIUM,DISS(MG/L AS LI)	.057	ZIRCONIUM DIS(MG/L AS ZR	.056
MOLYBDENUM,DISS(MG/L-MO)	.03		

REMARKS: FILTER CLEAN*WATER CLEAR
EVELYN LYMAN*SAND COULEE, MT

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L = MILLIEQUIVELENTS PER LITER, FT = FEET, MT = METERS, (M) = MEASURED, (E) = ESTIMATED, (R) = REPORTED, TR = TOTAL RECOVERABLE, TOT = TOTAL.

	QW	WA	SD	WI	OW	PW	AT	OTHER
OTHER AVAILABLE DATA		Y						
OTHER FILE NUMBERS:								

PROJECT:
LAST EDIT DATE: 05-JAN-83
PROCESSING PROGRAM: F1730F V2 (11/3/81)

COST:
BY: ID #ID
PRINTED: 27 MAY 83

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
62.0	33.2	4.2	0.5	1.9	68.8	29.3	0.0

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: 8200490

MONTANA BUREAU OF MINES AND GEOLOGY
BUTTE,MONTANA 59701 (406)496-4101

WATER QUALITY ANALYSIS
LAB NO. 8200499

STATE	MONTANA	COUNTY	CASCADE
LATITUDE-LONGITUDE	47D23'46"N 111D09'09"W	SITE LOCATION	19N 5E 10*CBDD
UTM COORDINATES	Z N E	MBMG SITE	
TOPOGRAPHIC MAP	SOUTHEAST GREAT FALLS 7 1	STATION ID	472346111090901
GEOLOGIC SOURCE	330MDSN* * *	SAMPLE SOURCE	WELL
DRAINAGE BASIN	BB	LAND SURFACE ALTITUDE	3455. FT < 10
AGENCY + SAMPLER	MBMG*MRM	SUSTAINED YIELD	11.2 GPM
BOTTLE NUMBER	NET	YIELD MEAS METHOD	BUCKET/STOPWATCH
DATE SAMPLED		TOTAL DEPTH OF WELL	175. FT (R)
TIME SAMPLED	: HOURS	SWL ABOVE(-) OR BELOW GS	79.76 FT (M)
LAB + ANALYST	MBMG*CNA	CASING DIAMETER	8 IN (M)
DATE ANALYZED	16-JUL 82	CASING TYPE	STEEL
SAMPLE HANDLING		COMPLETION TYPE	*
METHOD SAMPLED	PUMPED	PERFORATION INTERVAL	
WATER USE	DOMESTIC AND STOCK		

SAMPLING SITE TERRY NET*.75 MI NW OF CENTERVILLE
GEOLOGIC SOURCE MADISON GROUP OR LIMESTONE

	MG/L	MEQ/L		MG/L	MEQ/L
CALCIUM (CA)	65.5	3.27	BICARBONATE (HCO3)	271.3	4.45
MAGNESIUM (MG)	23.6	1.94	CARBONATE (CO3)	.0	
SODIUM (NA)	7.1	0.31	CHLORIDE (CL)	3.1	0.09
POTASSIUM (K)	3.1	0.08	SULFATE (SO4)	65.7	1.37
IRON (FE)	.018	0.00	NITRATE (AS N)	5.69	0.41
MANGANESE (MN)	.002	0.00	FLUORIDE (F)	.50	0.03
SILICA (SIO2)	15.7		PHOSPHATE TOT (AS P)		
TOTAL CATIONS		5.60	TOTAL ANIONS		6.33

STANDARD DEVIATION OF ANION-CATION BALANCE (SIGMA) 3.81

LABORATORY PH	7.68	TOTAL HARDNESS AS CACO3	260.69
FIELD WATER TEMPERATURE	12.5 C	TOTAL ALKALINITY AS CACO3	222.51
CALCULATED DISSOLVED SOLIDS	323.66	SODIUM ADSORPTION RATIO	0.19
SUM OF DISS. CONSTITUENT	461.31	RYZNAR STABILITY INDEX	6.99
LAB SPEC.COND.(MICROMHOS/CM)	580.7	LANGLIER SATURATION INDEX	0.34

PARAMETER	VALUE	PARAMETER	VALUE
TEMPERATURE, AIR (C)	85. F	CNDUCTVY,FIELD MICROMHOS	597.
FIELD PH	7.12	ALKALINITY,FLD(AS CACO3)	232.
ALUMINUM, DISS (MG/L-AL)	.04	NICKEL,DISS (MG/L AS NI)	.02
SILVER,DISS (MG/L AS AG)	.024	LEAD,DISS (MG/L AS PB)	.05
BORON ,DISS (MG/L AS B)	<.02	STRONTIUM,DISS (MG/L-SR)	.36
CADMIUM,DISS(MG/L AS CD)	.007	TITANIUM DIS(MG/L AS TI)	<.001
CHROMIUM, DISS (MG/L-CR)	.015	VANADIUM,DISS(MG/L AS V)	.015
COPPER,DISS (MG/L AS CU)	.028	ZINC,DISS (MG/L AS ZN)	.16
LITHIUM,DISS(MG/L AS LI)	.025	ZIRCONIUM DIS(MG/L AS ZR	.024
MOLYBDENUM,DISS(MG/L-MO)	.02		

REMARKS: WATER CLEAR*SMELL AND TASTE OK*SOLID BROWN SPOTS ON FILTER SILT
OWNERS ADDRESS BOX 95 STAR RT STOCKETT
LAB: FU CA 76.6, MG 27.9 GIVES 6.51 MEQ CATIONS FOR -.84 SIGMA

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L = MILLIEQUIVELENTS PER LITER, FT = FEET, MT = METERS, (M) = MEASURED, (E) = ESTIMATED, (R) = REPORTED, TR = TOTAL RECOVERABLE, TOT = TOTAL.

QW NA S2 WI OW PW AI OTHER

OTHER AVAILABLE DATA
OTHER FILE NUMBERS:

PROJECT: COST:
LAST EDIT DATE: 30-JUL-82 BY: TP *RCS
PROCESSING PROGRAM: F1730P V2 (11/3/81) PRINTED: 27-MAY-83

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
58.4	34.7	5.5	1.4	1.5	23.2	75.3	0.0

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: 8200499

MONTANA BUREAU OF MINES AND GEOLOGY — WATER QUALITY ANALYSIS
BUTTE,MONTANA 59701 (406)496 4101 — LAB NO. B200500

STATE	MONTANA	COUNTY	CASCADE
LATITUDE-LONGITUDE	47D24'48"N 111D09'46"W	SITE LOCATION	19N 4E 12 DBAA
UTM COORDINATES	Z N E	MBMG SITE	
TOPOGRAPHIC MAP	SOUTHEAST GREAT FALLS 7.1	STATION ID	472448111094601
GEOLOGIC SOURCE	330MDSN* *	SAMPLE SOURCE	W.L.
DRAINAGE BASIN	BB	LAND SURFACE ALTITUDE	3440. FT 10
AGENCY & SAMPLER	MBMG*WJB	SUSTAINED YIELD	GPM
BOTTLE NUMBER	KAJALA	YIELD MEAS METHOD	BUCKET/STOPWATCH
DATE SAMPLED	20 JUN 82	TOTAL DEPTH OF WELL	150. FT (R)
TIME SAMPLED	15:15 HOURS	SWL ABOVE(-) OR BELOW GS	101.36 FT (M)
LAB & ANALYST	MBMG*FNA	CASING DIAMETER	6.5 IN (R)
DATE ANALYZED	14-JUL-82	CASING TYPE	STEEL
SAMPLE HANDLING		COMPLETION TYPE	01*
METHOD SAMPLED	PUMPED	PERFORATION INTERVAL	
WATER USE	DOMESTIC		

SAMPLING SITE EAST ACROSS HIWAY TRACY*3RD HOUSE ON RIGHT
GEOLOGIC SOURCE MADISON GROUP OR LIMESTONE

	MG/L	MEQ/L		MG/L	MEQ/L
CALCIUM (CA)	75.8	3.78	BICARBONATE (HCO3)	233.2	3.83
MAGNESIUM (MG)	26.5	2.18	CARBONATE (CO3)	.0	
SODIUM (NA)	11.0	0.51	CHLORIDE (CL)	9.2	0.26
POTASSIUM (K)	2.5	0.06	SULFATE (SO4)	133.	2.77
IRON (FE)	.002		NITRATE (AS N)	.08	0.06
MANGANESE (MN)	.005	0.00	FLUORIDE (F)	.54	0.03
SILICA (SIO2)	11.8		PHOSPHATE TOT (AS P)		
TOTAL CATIONS		6.54	TOTAL ANIONS		6.95

STANDARD DEVIATION OF ANION-CATION BALANCE (SIGMA) 2.01

LABORATORY PH	7.58	TOTAL HARDNESS AS CACO3	298.35
FIELD WATER TEMPERATURE		TOTAL ALKALINITY AS CACO3	191.67
CALCULATED DISSOLVED SOLIDS	387.15	SODIUM ADSORPTION RATIO	0.30
SUM OF DISS. CONSTITUENT	505.73	RYZNAR STABILITY INDEX	7.10
LAB SPEC.COND.(MICROMHOS/CM)	617.2	LANGLIER SATURATION INDEX	0.24

PARAMETER	VALUE	PARAMETER	VALUE
TEMPERATURE, AIR (C)	85. F	CNDUCTVY,FIELD MICROMHOS	640.
FIELD PH	7.35	ALKALINITY,FLD(AS CACO3)	200.
ALUMINUM, DISS (MG/L-AL)	.08	NICKEL,DISS (MG/L AS NI)	.01
SILVER,DISS (MG/L AS AG)	.014	LEAD,DISS (MG/L AS PB)	.04
BORON ,DISS (MG/L AS B)	.02	STRONTIUM,DISS (MG/L SR)	.23
CADMIUM,DISS(MG/L AS CD)	.006	TITANIUM DIS(MG/L AS TI)	.004
CHROMIUM, DISS (MG/L-CR)	.010	VANADIUM,DISS(MG/L AS V)	.016
COPPER,DISS (MG/L AS CU)	.020	ZINC,DISS (MG/L AS ZN)	.15
LITHIUM,DISS(MG/L AS LI)	.032	ZIRCONIUM DIS(MG/L AS ZR	.020
MOLYBDENUM,DISS(MG/L-MO)	.02		

REMARKS: FILTER RUSTY BROWN*WATER CLOUDY
RICHARD KUJALA*BOX 53*SAND COULEE
LAB: FU CA 80.4, MG 28.4, NA 12.7 GIVES 6.96 MEQ CATIONS FOR .07 SIGMA

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L = MILLIEQUIVELENTS PER LITER. FT = FEET, MI = METERS. (M) = MEASURED, (E) = ESTIMATED, (R) = REPORTED. TR = TOTAL RECOVERABLE. TOT = TOTAL.

	QW	WA	S2	WI	OW	PW	AT	OTHER
OTHER AVAILABLE DATA		Y						

OTHER FILE NUMBERS:

PROJECT: COST:
LAST EDIT DATE: 30-JUL-82 BY: TP *RCS
PROCESSING PROGRAM: F1730P V2 (11/3/81) PRINTED: 27 MAY 83

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
57.8	33.3	7.8	1.0	3.8	40.4	55.8	0.0

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: B200500

MONTANA BUREAU OF MINES AND GEOLOGY
BUTTE,MONTANA 59701 (406)496-4101

WATER QUALITY ANALYSIS
LAB NO. 8200501

STATE	MONTANA	COUNTY	CASCADE
LATITUDE-LONGITUDE	47D26'22"N 111D10'29"W	SITE LOCATION	20N 5E 31*CDAA
UTM COORDINATES	Z N E	MBMG SITE	
TOPOGRAPHIC MAP	SOUTHEAST GREAT FALLS 7.1	STATION ID	472622111102901
GEOLOGIC SOURCE	330MDSN* * *	SAMPLE SOURCE	WELL
DRAINAGE BASIN	BB	LAND SURFACE ALTITUDE	3400. FT +- 10
AGENCY & SAMPLER	MBMG*URM	SUSTAINED YIELD	5.1 GPM
BOTTLE NUMBER	JOHNSON	YIELD MEAS METHOD	BUCKET/STOPWATCH
DATE SAMPLED	18-JUN-82	TOTAL DEPTH OF WELL	125. FT (R)
TIME SAMPLED	14:05 HOURS	SWL ABOVE(-) OR BELOW GS	65.45 FT (M)
LAB & ANALYST	MBMG*ENA	CASING DIAMETER	6 IN (M)
DATE ANALYZED	16-JUL-82	CASING TYPE	STEEL
SAMPLE HANDLING		COMPLETION TYPE	*
METHOD SAMPLED	PUMPED	PERFORATION INTERVAL	
WATER USE	DOMESTIC AND STOCK		

SAMPLING SITE GENE JOHNSON RANCH 1.75 MI NE OF TRACY
GEOLOGIC SOURCE MADISON GROUP OR LIMESTONE

	MG/L	MEQ/L		MG/L	MEQ/L
CALCIUM (CA)	146.	7.29	BICARBONATE (HCO3)	421.	6.90
MAGNESIUM (MG)	83.3	6.85	CARBONATE (CO3)	.0	
SODIUM (NA)	107.	4.65	CHLORIDE (CL)	13.9	0.39
POTASSIUM (K)	3.3	0.08	SULFATE (SO4)	564.	11.74
IRON (FE)	.002	0.00	NITRATE (AS N)	2.96	0.21
MANGANESE (MN)	.002	0.00	FLUORIDE (F)	.37	0.02
SILICA (SIO2)	19.3		PHOSPHATE TOT (AS P)		
TOTAL CATIONS		18.88	TOTAL ANIONS		19.27

STANDARD DEVIATION OF ANION-CATION BALANCE (SIGMA) 1.01

LABORATORY PH	7.47	TOTAL HARDNESS AS CACO3	707.42
FIELD WATER TEMPERATURE	9.0 C	TOTAL ALKALINITY AS CACO3	345.29
CALCULATED DISSOLVED SOLIDS	1147.52	SODIUM ADSORPTION RATIO	1.75
SUM OF DISS. CONSTITUENT	1361.13	RYZNAR STABILITY INDEX	6.12
LAB SPEC.COND.(MICROMHOS/CM)	1585.	LANGLIER SATURATION INDEX	0.67

PARAMETER	VALUE	PARAMETER	VALUE
TEMPERATURE, AIR (C)	77. F	CNDUCTVY,FIELD MICROMHOS	1698.
FIELD PH	7.08	ALKALINITY,FLD(AS CACO3)	394.
ALUMINUM, DISS (MG/L-AL)	.06	NICKEL,DISS (MG/L AS NI)	<.01
SILVER,DISS (MG/L AS AG)	<.011	LEAD,DISS (MG/L AS PB)	.06
BORON ,DISS (MG/L AS B)	.23	STRONTIUM,DISS (MG/L-SR)	1.01
CADMIUM,DISS(MG/L AS CD)	.002	TITANIUM DIS(MG/L AS TI)	.009
CHROMIUM, DISS (MG/L-CR)	.008	VANADIUM,DISS(MG/L AS V)	.011
COPPER,DISS (MG/L AS CU)	.021	ZINC,DISS (MG/L AS ZN)	.013
LITHIUM,DISS(MG/L AS LI)	.067	ZIRCONIUM DIS(MG/L AS ZR	.018
MOLYBDENUM,DISS(MG/L-MO)	.02		

REMARKS: WATER CLEAR*TASTE AND SMELL OK*FILTER CLEAN
OWNERS ADDRESS STAR RT SAND COULEE

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L = MILLIEQUIVELENTS PER LITER. FT = FEET, MT = METERS. (M) = MEASURED, (E) = ESTIMATED, (R) = REPORTED. TR = TOTAL RECOVERABLE. TOT = TOTAL.

	QW	WA	SO	WI	OW	PW	AT	OTHER
OTHER AVAILABLE DATA								
OTHER FILE NUMBERS:								

PROJECT:		COST:	
LAST EDIT DATE:	05-JAN-83	BY:	TP *TP
PROCESSING PROGRAM:	E1730P V2 (11/3/81)	PRINTED:	27-MAY-83

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
38.6	36.3	24.7	0.4	2.1	61.7	36.2	0.0

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: 8200501

MONTANA BUREAU OF MINES AND GEOLOGY — WATER QUALITY ANALYSIS
BUTTE, MONTANA 59701 (406)496 4101 — LAB NO. B20050

STATE MONTANA — COUNTY CA AND
LATITUDE-LONGITUDE 47D18'19"N 111D11'05"W — SITE LOCATION TWN 21 S RGE
UTM COORDINATES Z N E — MINE SITE
TOPOGRAPHIC MAP STOCKETT 7 1/2' — STATION ID 47211211110901
GEOLOGIC SOURCE 220JKSC* * SAMPLE SOURCE WELL
DRAINAGE BASIN BR — LAND SURFACE ALTITUDE 3916. FT
AGENCY & SAMPLER MBMG*BRM — SUSTAINED YIELD 1.000
BOTTLE NUMBER BSINGLE — YIELD MEAS METHOD BUCKET/STOPWATCH
DATE SAMPLED 21-JUN 82 — TOTAL DEPTH OF WELL 55. FT
TIME SAMPLED 14:39 HOURS SWL ABOVE( ) OR BELOW GS FT (F)
LAB & ANALYST MBMG*ENA — CASING DIAMETER 6 IN (F)
DATE ANALYZED 16-JUL 82 — CASING TYPE PLASTIC
SAMPLE HANDLING — COMPLETION TYPE *
METHOD SAMPLED PUMPED — PERFORATION INTERVAL
WATER USE

SAMPLING SITE RALPH SINGLE 3.25 MI SW OF STOCKETT
GEOLOGIC SOURCE JURASSIC UNDIFFERENTIATED

	MG/L	MEQ/L			MG/L	MEQ/L
CALCIUM (CA)	57.3	2.86	BICARBONATE	(HCO3)	271.3	4.48
MAGNESIUM (MG)	26.4	2.17	CARBONATE	(CO3)	.0	
SODIUM (NA)	7.3	0.32	CHLORIDE	(CL)	2.6	0.07
POTASSIUM (K)	3.3	0.08	SULFATE	(SO4)	34.2	0.71
IRON (FE)	.002		NITRATE	(AS N)	4.18	0.30
MANGANESE (MN)	.002	0.00	FLUORIDE	(F)	.20	0.05
SILICA (SIO2)	6.3		PHOSPHATE TOT	(AS P)		
TOTAL CATIONS		5.43	TOTAL ANIONS			5.62

STANDARD DEVIATION OF ANION-CATION BALANCE (SIGMA) 0.07

LABORATORY PH	7.20	TOTAL HARDNESS AS CACO3	251.24
FIELD WATER TEMPERATURE	9.2 C	TOTAL ALKALINITY AS CACO3	224.15
CALCULATED DISSOLVED SOLIDS	277.20	SODIUM ADSORPTION RATIO	0.20
SUM OF DISS. CONSTITUENT	415.87	RYZNAR STABILITY INDEX	7.50
LAB SPEC.COND.(MICROMHOS/CM)	509.4	LANGLIER SATURATION INDEX	-0.19

PARAMETER	VALUE	PARAMETER	VALUE
TEMPERATURE, AIR (C)	81. F	CNDUCTVY,FIELD MICROMHOS	528.
FIELD PH	6.45	ALKALINITY,FLD(AS CACO3)	230.
ALUMINUM, DISS (MG/L AL)	<.03	NICKEL,DISS (MG/L AS NI)	.02
SILVER,DISS (MG/L AS AG)	<.002	LEAD,DISS (MG/L AS PB)	.01
BORON ,DISS (MG/L AS B)	<.02	STRONTIUM,DISS (MG/L SR)	.18
CADMIUM,DISS(MG/L AS CD)	<.002	TITANIUM DIS(MG/L AS TI)	.004
CHROMIUM, DISS (MG/L CR)	.002	VANADIUM,DISS(MG/L AS V)	.001
COPPER,DISS (MG/L AS CU)	.020	ZINC,DISS (MG/L AS ZN)	.032
LITHIUM,DISS(MG/L AS LI)	.007	ZIRCONIUM DIS(MG/L AS ZR	.004
MOLYBDENUM,DISS(MG/L MO)	<.02		

REMARKS: WATER CLEAR*TASTE & SMELL OK*CLEAN FILTER
OWNERS ADDRESS STAR RT STOCKETT
LAB: FU CA 59.3, MG 27.7 GIVES 5.64 MEQ CATIONS FOR .03 SIGMA

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L = MILLIEQUIVELENTS PER LITER, FT = FEET, MI = METERS, (M) = MEASURED, (E) = ESTIMATED, (R) = REPORTED, TR = TOTAL RECOVERABLE, TOT = TOTAL.

QW WA S2 WI OW PW AI OTHER

OTHER AVAILABLE DATA
OTHER FILE NUMBERS:

PROJECT: — COST:
LAST EDIT DATE: 05-JAN 83 — BY: DP *DP
PROCESSING PROGRAM: F1730P V2 (11/3/81) — PRINTED: 27 MAY 83

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
52.6	40.0	5.8	1.6	1.4	13.5	85.1	0.0

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: B20050

MONTANA BUREAU OF MINES AND GEOLOGY
BUTTE,MONTANA 59701 (406)496 4101

WATER QUALITY ANALYSIS
LAB NO. B200503

STATE	MONTANA	COUNTY	CASCADE
LATITUDE-LONGITUDE	47D19'59"N 111D10'41"W	SITE LOCATION	18N 4E 11 AAAC
UTM COORDINATES	Z N E	MBMG SITE	
TOPOGRAPHIC MAP	STOCKETT 7 1/2'	STATION ID	471959111104101
GEOLOGIC SOURCE	217KOTN*221MRSN*	* SAMPLE SOURCE	WELL
DRAINAGE BASIN	BB	LAND SURFACE ALTITUDE	4070. FT < 10
AGENCY & SAMPLER	MBMG*HRM	SUSTAINED YIELD	7.2 GPM
BOTTLE NUMBER	D.YUREK	YIELD MEAS METHOD	BUCKET/STOPWATCH
DATE SAMPLED	21-JUN-82	TOTAL DEPTH OF WELL	131. FT (R)
TIME SAMPLED	16:00 HOURS	SWL ABOVE(-) OR BELOW GS	12.70 FT (M)
LAB & ANALYST	MBMG*ENA	CASING DIAMETER	6 IN (M)
DATE ANALYZED	16-JUL-82	CASING TYPE	STEEL
SAMPLE HANDLING		COMPLETION TYPE	03*
METHOD SAMPLED	PUMPED	PERFORATION INTERVAL	
WATER USE	DOMESTIC AND STOCK		

SAMPLING SITE DONALD YUREK RANCH 1.75 MI SW OF STOCKETT
GEOLOGIC SOURCE KOOTENAI FORMATION

		MG/L	MEQ/L			MG/L	MEQ/L
CALCIUM	(CA)	67.8	3.38	BICARBONATE	(HCO3)	371.9	6.10
MAGNESIUM	(MG)	36.4	2.99	CARBONATE	(CO3)	.0	
SODIUM	(NA)	21.2	0.92	CHLORIDE	(CL)	2.8	0.08
POTASSIUM	(K)	6.5	0.17	SULFATE	(SO4)	36.8	0.77
IRON	(FE)	<.002		NITRATE	(AS N)	5.47	0.39
MANGANESE	(MN)	.050	0.00	FLUORIDE	(F)	.97	0.05
SILICA	(SIO2)	7.5		PHOSPHATE TOT	(AS P)		
TOTAL CATIONS			7.47	TOTAL ANIONS			7.38

STANDARD DEVIATION OF ANION-CATION BALANCE (SIGMA) -0.41

LABORATORY PH	7.37	TOTAL HARDNESS AS CACO3	319.12
FIELD WATER TEMPERATURE	12.1 C	TOTAL ALKALINITY AS CACO3	305.02
CALCULATED DISSOLVED SOLIDS	368.69	SODIUM ADSORPTION RATIO	0.52
SUM OF DISS. CONSTITUENT	557.39	RYZNAR STABILITY INDEX	7.00
LAB SPEC.COND.(MICROMHOS/CM)	657.1	LANGLIER SATURATION INDEX	0.19

PARAMETER	VALUE	PARAMETER	VALUE
TEMPERATURE, AIR (C)	84. F	CNDUCTVY,FIELD MICROMHOS	677.
FIELD PH	6.63	ALKALINITY,FLD(AS CACO3)	324.
ALUMINUM, DISS (MG/L-AL)	<.03	NICKEL,DISS (MG/L AS NI)	<.01
SILVER,DISS (MG/L AS AG)	<.002	LEAD,DISS (MG/L AS PB)	.04
BORON ,DISS (MG/L AS B)	.25	STRONTIUM,DISS (MG/L-SR)	.59
CADMIUM,DISS(MG/L AS CD)	<.002	TITANIUM DIS(MG/L AS TI)	<.001
CHROMIUM, DISS (MG/L-CR)	<.002	VANADIUM,DISS(MG/L AS V)	<.001
COPPER,DISS (MG/L AS CU)	<.002	ZINC,DISS (MG/L AS ZN)	5.00
LITHIUM,DISS(MG/L AS LI)	.047	ZIRCONIUM DIS(MG/L AS ZR	<.003
MOLYBDENUM,DISS(MG/L-MO)	<.02		

REMARKS: WATER CLOUDY *TASTE AND SMELL OK*LIGHT BROWN SILTY FILTER
OWNERS ADDRESS STOCKETT*RUNNING WATER CLEAR FOR 7 MIN*FLOW 16.4 GPM*
WATER BECAME VERY CLOUDY AND FLOW 7.2 GPM FOR 8 MIN*WATER CLEARED

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L
MILLIEQUIVELENTS PER LITER, FT = FEET, MT = METERS, (M) = MEASURED, (E) =
ESTIMATED, (R) = REPORTED, TR = TOTAL RECOVERABLE, TOT = TOTAL.

	OW	WA	SS	WI	OW	PW	AT	OTHER
OTHER AVAILABLE DATA		Y						
OTHER FILE NUMBERS:								

PROJECT:		COST:	
LAST EDIT DATE:	30-JUL-82	BY:	TP *BCS
PROCESSING PROGRAM:	F1730P V2 (11/3/81)	PRINTED:	27-MAY-83

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
45.3	40.1	12.4	2.3	1.1	11.0	87.8	0.0

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: B200503

MONTANA BUREAU OF MINES AND GEOLOGY
BUTTE,MONTANA 59701 (406)496 4101

WATER QUALITY ANALYSIS
LAB NO. 8200504

STATE	MONTANA	COUNTY	CASCADE
LATITUDE-LONGITUDE	47D24'24"N 111D09'30"W	SITE LOCATION	19N 4E 13 AABB
UTM COORDINATES	Z N E	MBMG SITE	
TOPOGRAPHIC MAP	SOUTHEAST GREAT FALLS 7 1	STATION ID	472424111093801
GEOLOGIC SOURCE	* * *	SAMPLE SOURCE	WELL
DRAINAGE BASIN	BB	LAND SURFACE ALTITUDE	3455. FT (E)
AGENCY & SAMPLER	MBMG*WJD	SUSTAINED YIELD	GPM
BOTTLE NUMBER	LYNCH	YIELD MEAS METHOD	BUCKET/STOPWATCH
DATE SAMPLED	18-JUN-82	TOTAL DEPTH OF WELL	168. FT (E)
TIME SAMPLED	09:30 HOURS	SWL ABOVE(-) OR BELOW GS	109.70 FT (M)
LAB & ANALYST	MBMG*ENA	CASING DIAMETER	6 IN
DATE ANALYZED	14-JUL-82	CASING TYPE	STEEL
SAMPLE HANDLING		COMPLETION TYPE	*
METHOD SAMPLED	PUMPED	PERFORATION INTERVAL	
WATER USE	DOMESTIC		

SAMPLING SITE MIDDLE OF FIELD & OFF TRACY-SAND COULEE RD
GEOLOGIC SOURCE

	MG/L	MEQ/L		MG/L	MEQ/L
CALCIUM (CA)	87.8	4.38	BICARBONATE (HCO3)	261.6	4.29
MAGNESIUM (MG)	31.6	2.60	CARBONATE (CO3)	.0	
SODIUM (NA)	13.1	0.57	CHLORIDE (CL)	9.2	0.26
POTASSIUM (K)	2.7	0.07	SULFATE (SO4)	148.	3.08
IRON (FE)	<.002		NITRATE (AS N)	.44	0.03
MANGANESE (MN)	.001	0.00	FLUORIDE (F)	.52	0.03
SILICA (SIO2)	13.1		PHOSPHATE TOT (AS P)		
TOTAL CATIONS		7.62	TOTAL ANIONS		7.69

STANDARD DEVIATION OF ANION-CATION BALANCE (SIGMA) 0.31

LABORATORY PH	7.49	TOTAL HARDNESS AS CACO3	349.30
FIELD WATER TEMPERATURE		TOTAL ALKALINITY AS CACO3	214.56
CALCULATED DISSOLVED SOLIDS	435.33	SODIUM ADSORPTION RATIO	0.31
SUM OF DISS. CONSTITUENT	568.06	RYZNAR STABILITY INDEX	6.96
LAB SPEC.COND.(MICROMHOS/CM)	675.1	LANGLIER SATURATION INDEX	0.27

PARAMETER	VALUE	PARAMETER	VALUE
CNDUCTVY,FIELD MICROMHOS	700.	FIELD PH	7.51
ALKALINITY,FLD(AS CACO3)	216.	ALUMINUM, DISS (MG/L AL)	.03
NICKEL,DISS (MG/L AS NI)	<.01	SILVER,DISS (MG/L AS AG)	<.002
LEAD,DISS (MG/L AS PB)	<.04	BORON ,DISS (MG/L AS B)	<.02
STRONTIUM,DISS (MG/L-SR)	.89	CADMIUM,DISS(MG/L AS CD)	<.002
TITANIUM DIS(MG/L AS TI)	.028	CHROMIUM, DISS (MG/L-CR)	<.002
VANADIUM,DISS(MG/L AS V)	<.001	COPPER,DISS (MG/L AS CU)	.009
ZINC,DISS (MG/L AS ZN)	1.14	LITHIUM,DISS(MG/L AS LI)	.022
ZIRCONIUM DIS(MG/L AS ZR	<.003	MOLYBDENUM,DISS(MG/L-MO)	<.02

REMARKS: FILTER CLEAN*WATER CLEAR
RENEE LYNCH*BOX 71*SAND COULEE*LOG UNKNOWN*DRILLED MARCH 1944

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L = MILLIEQUIVELENTS PER LITER, FT = FEET, MT = METERS, (M) = MEASURED, (E) = ESTIMATED, (R) = REPORTED, TR = TOTAL RECOVERABLE, TOT = TOTAL.

QW WA S2 WI OW PW AT OTHER

OTHER AVAILABLE DATA
OTHER FILE NUMBERS:

PROJECT:		COST:	
LAST EDIT DATE:	30-JUL-82	BY:	TP *BCS
PROCESSING PROGRAM:	F1730P V2 (11/3/81)	PRINTED:	27-MAY-83

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
57.5	34.1	7.5	0.9	3.4	40.4	56.2	0.0

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: 8200504

MONTANA BUREAU OF MINES AND GEOLOGY
BUTTE,MONTANA 59701 (406)496-4101

WATER QUALITY ANALYSIS
LAB NO. 8200505

STATE	MONTANA	COUNTY	CASCADE
LATITUDE-LONGITUDE	47D23'05"N 111D11'40"W	SITE LOCATION	19N 04E 23*CBBA
UTM COORDINATES	Z N E	MBMG SITE	
TOPOGRAPHIC MAP	SOUTHEAST GREAT FALLS 7 1	STATION ID	472305111114001
GEOLOGIC SOURCE	217KOTN*220JRSC*	* SAMPLE SOURCE	WELL
DRAINAGE BASIN	BB	LAND SURFACE ALTITUDE	3770. FT < 10
AGENCY & SAMPLER	MBMG*WJD	SUSTAINED YIELD	4.9 GPM
BOTTLE NUMBER	SWARTZB	YIELD MEAS METHOD	BUCKET/STOPWATCH
DATE SAMPLED	22-JUN-82	TOTAL DEPTH OF WELL	240. FT (R)
TIME SAMPLED	18:30 HOURS	SWL ABOVE(-) OR BELOW GS	170. FT (R)
LAB & ANALYST	MBMG*FNA	CASING DIAMETER	1.5 IN (R)
DATE ANALYZED	16-JUL-82	CASING TYPE	STEEL
SAMPLE HANDLING		COMPLETION TYPE	01*
METHOD SAMPLED	PUMPED	PERFORATION INTERVAL	
WATER USE	DOMESTIC		

SAMPLING SITE SWARTZENBURGER, GERALD*
GEOLOGIC SOURCE KOOTENAI FORMATION

	MG/L	MEQ/L		MG/L	MEQ/L
CALCIUM (CA)	46.5	2.32	BICARBONATE (HCO3)	516.	8.46
MAGNESIUM (MG)	78.8	6.48	CARBONATE (CO3)	0.	
SODIUM (NA)	11.0	0.48	CHLORIDE (CL)	3.8	0.11
POTASSIUM (K)	3.2	0.08	SULFATE (SO4)	23.7	0.49
IRON (FE)	<.002		NITRATE (AS N)	4.29	0.31
MANGANESE (MN)	<.001		FLUORIDE (F)	1.4	0.07
SILICA (SIO2)	6.5		PHOSPHATE TOT (AS P)		
TOTAL CATIONS		9.36	TOTAL ANIONS		9.44

STANDARD DEVIATION OF ANION-CATION BALANCE (SIGMA) 0.30

LABORATORY PH	7.70	TOTAL HARDNESS AS CACO3	440.45
FIELD WATER TEMPERATURE		TOTAL ALKALINITY AS CACO3	423.21
CALCULATED DISSOLVED SOLIDS	433.38	SODIUM ADSORPTION RATIO	0.23
SUM OF DISS. CONSTITUENT	695.19	RYZNAR STABILITY INDEX	6.71
LAB SPEC.COND.(MICROMHOS/CM)	793.3	LANGLIER SATURATION INDEX	0.49

PARAMETER	VALUE	PARAMETER	VALUE
TEMPERATURE, AIR (C)	72. F	CNDUCTVY,FIELD MICROMHOS	796.
FIELD PH	7.17	ALKALINITY,FLD(AS CACO3)	433.
ALUMINUM, DISS (MG/L-AL)	<.03	NICKEL,DISS (MG/L AS NI)	<.01
SILVER,DISS (MG/L AS AG)	<.002	LEAD,DISS (MG/L AS PB)	<.04
BORON ,DISS (MG/L AS B)	<.02	STRONTIUM,DISS (MG/L-SR)	.48
CADMIUM,DISS(MG/L AS CD)	<.006	TITANIUM DIS(MG/L AS TI)	.003
CHROMIUM, DISS (MG/L-CR)	<.002	VANADIUM,DISS(MG/L AS V)	<.001
COPPER,DISS (MG/L AS CU)	<.001	ZINC,DISS (MG/L AS ZN)	.33
LITHIUM,DISS(MG/L AS LI)	.046	ZIRCONIUM DIS(MG/L AS ZR	<.003
MOLYBDENUM,DISS(MG/L-MO)	<.02		

REMARKS: FILTER COVERED WITH SILT * WATER CLOUDY
GERALD SWARTZENBURGER * SAND COULEE MT

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L = MILLIEQUIVELENTS PER LITER, FT = FEET, MT = METERS. (M) = MEASURED, (E) = ESTIMATED, (R) = REPORTED. TR = TOTAL RECOVERABLE. TOT = TOTAL.

	QW	WA	S2	WI	OW	PW	AT	OTHER
OTHER AVAILABLE DATA		Y						

OTHER FILE NUMBERS:

PROJECT: COST:
LAST EDIT DATE: 05-JAN-83 BY: TP *TP
PROCESSING PROGRAM: F1730P V2 (11/3/81) PRINTED: 27-MAY-83

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
24.8	69.2	5.1	0.9	1.2	5.4	93.4	0.0

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: 8200505
Ready

MONTANA BUREAU OF MINES AND GEOLOGY
BUTTE, MONTANA 59701 (406)496-4101

WATER QUALITY ANALYSIS
LAB NO. 8300001

STATE	MONTANA	COUNTY	CASCADE
LATITUDE-LONGITUDE	47D23'32"N 111D08'30"W	SITE LOCATION	19N 05E 18 DCDC
UTM COORDINATES	Z N E	MBMG SITE	
TOPOGRAPHIC MAP	SOUTHEAST GREAT FALLS 7.5	STATION ID	472332111083001
GEOLOGIC SOURCE	330MDSN* * *	SAMPLE SOURCE	WELL
DRAINAGE BASIN	BB	LAND SURFACE ALTITUDE	3475.0 FT
AGENCY & SAMPLER	MBMG*MRM	SUSTAINED YIELD	
BOTTLE NUMBER	CENSRCI	YIELD MEAS METHOD	
DATE SAMPLED	29 DEC 82	TOTAL DEPTH OF WELL	400. FT (R)
TIME SAMPLED	10:45 HOURS	SWL ABOVE( ) OR BELOW GS	134.3 FT (M)
LAB & ANALYST	MBMG*ENA	CASING DIAMETER	6 IN (M)
DATE ANALYZED	19-JAN 83	CASING TYPE	PVC
SAMPLE HANDLING		COMPLETION TYPE	*
METHOD SAMPLED	PUMPED	PERFORATION INTERVAL	
WATER USE	DOMESTIC		

SAMPLING SITE CENTERVILLE SENIOR CITIZENS CENTER
GEOLOGIC SOURCE MADISON GROUP OR LIMESTONE

		MG/L	MEQ/L			MG/L	MEQ/L
CALCIUM	(CA)	241.	12.03	BICARBONATE	(HCO3)	405.	6.64
MAGNESIUM	(MG)	135.	11.11	CARBONATE	(CO3)	0.	
SODIUM	(NA)	23.1	1.00	CHLORIDE	(CL)	23.3	0.66
POTASSIUM	(K)	4.1	0.11	SULFATE	(SO4)	755.	15.72
IRON	(FE)	.002		NITRATE	(AS N)	10.4	0.89
MANGANESE	(MN)	.004	0.00	FLUORIDE	(F)	1.1	0.06
SILICA	(SIO2)	16.9		PHOSPHATE TOT	(AS P)		
TOTAL CATIONS			24.24	TOTAL ANIONS			23.96

STANDARD DEVIATION OF ANION-CATION BALANCE (SIGMA) -0.63

LABORATORY PH	8.52	TOTAL HARDNESS AS CACO3	1157.44
FIELD WATER TEMPERATURE	6.8 C	TOTAL ALKALINITY AS CACO3	332.17
CALCULATED DISSOLVED SOLIDS	1411.41	SODIUM ADSORPTION RATIO	0.30
SUM OF DISS. CONSTITUENT	1616.90	RYZNAR STABILITY INDEX	6.57
LAB SPEC.COND.(MICROMHOS/CM)	1901.	LANGLIER SATURATION INDEX	-0.03

PARAMETER	VALUE	PARAMETER	VALUE
TEMPERATURE, AIR (C)	20. F	CNDUCTVY,FIELD MICROMHOS	1580.
FIELD PH	5.70	ALKALINITY,FLD(AS CACO3)	361.00
ALUMINUM, DISS (MG/L-AL)	<.03	NICKEL,DISS (MG/L AS NI)	.01
SILVER,DISS (MG/L AS AG)	<.002	LEAD,DISS (MG/L AS PB)	<.04
BORON ,DISS (MG/L AS B)	.11	STRONTIUM,DISS (MG/L-SR)	.82
CADMIUM,DISS(MG/L AS CD)	.002	TITANIUM DIS(MG/L AS TI)	.024
CHROMIUM, DISS (MG/L-CR)	.004	VANADIUM,DISS(MG/L AS V)	.004
COPPER,DISS (MG/L AS CU)	.038	ZINC,DISS (MG/L AS ZN)	.034
LITHIUM,DISS(MG/L AS LI)	.046	ZIRCONIUM DIS(MG/L AS ZR	.003
MOLYBDENUM,DISS(MG/L-MO)	<.02	ARSENIC,DISS(UG/L AS AS)	.8

REMARKS: WHITE FOAM COATS STEEL TAPE, DRIES TO HARD WHITE PPT., FILTER CLEAN

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L = MILLIEQUIVELENTS PER LITER. FT = FEET, MI = METERS. (M) = MEASURED, (E) = ESTIMATED, (R) = REPORTED. TR = TOTAL RECOVERABLE. TOT = TOTAL.

OTHER AVAILABLE DATA — GW WA SO WI QW PW AT OTHER
OTHER FILE NUMBERS:

PROJECT:		COST:	
LAST EDIT DATE:	02-FEB-83	BY:	ID *BCS
PROCESSING PROGRAM:	F1730F V2 (11/3/81)	PRINTED:	27-MAY-83

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
49.6	45.8	4.1	0.4	2.9	68.3	28.8	0.0

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: 8300001

MONTANA BUREAU OF MINES AND GEOLOGY
BUTTE,MONTANA 59701 (406)496-4101

WATER QUALITY ANALYSIS
LAB NO. 8300002

STATE	MONTANA	COUNTY	CASCADE
LATITUDE-LONGITUDE	47D24'52"N 111D08'55"W	SITE LOCATION	19N 5E 7*BDDC
UTM COORDINATES	Z N E	MBMG SITE	
TOPOGRAPHIC MAP	SOUTHEAST GREAT FALLS 7 1	STATION ID	472452111085501
GEOLOGIC SOURCE	330MDSN* * *	SAMPLE SOURCE	WELL
DRAINAGE BASIN	BB	LAND SURFACE ALTITUDE	3455. FT < 10
AGENCY + SAMPLER	MBMG*NRM	SUSTAINED YIELD	
BOTTLE NUMBER	GHEAL-2	YIELD MEAS METHOD	
DATE SAMPLED	30-DEC-82	TOTAL DEPTH OF WELL	320.0 (E)
TIME SAMPLED	11:30 HOURS	SWL ABOVE(-) OR BELOW GS	69.50 (M)
LAB + ANALYST	MBMG*ENA	CASING DIAMETER	6 IN (M)
DATE ANALYZED	19-JAN-83	CASING TYPE	IRON
SAMPLE HANDLING		COMPLETION TYPE	*
METHOD SAMPLED	PUMPED	PERFORATION INTERVAL	
WATER USE	STOCK		

SAMPLING SITE HEAL WELL-2 TRACY
GEOLOGIC SOURCE MADISON GROUP OR LIMESTONE

	MG/L	MEQ/L		MG/L	MEQ/L
CALCIUM (CA)	97.3	4.86	BICARBONATE (HCO3)	233.8	3.83
MAGNESIUM (MG)	89.4	7.35	CARBONATE (CO3)	0.	
SODIUM (NA)	22.0	0.96	CHLORIDE (CL)	13.8	0.39
POTASSIUM (K)	8.0	0.21	SULFATE (SO4)	428.	8.91
IRON (FE)	<.002		NITRATE (AS N)	1.83	0.13
MANGANESE (MN)	.003	0.00	FLUORIDE (F)	.55	0.03
SILICA (SIO2)	8.7		PHOSPHATE TOT (AS P)		
TOTAL CATIONS		13.37	TOTAL ANIONS		13.29

STANDARD DEVIATION OF ANION-CATION BALANCE (SIGMA) -0.27

LABORATORY PH	7.56	TOTAL HARDNESS AS CACO3	610.93
FIELD WATER TEMPERATURE	7.3 C	TOTAL ALKALINITY AS CACO3	191.76
CALCULATED DISSOLVED SOLIDS	784.76	SODIUM ADSORPTION RATIO	0.39
SUM OF DISS. CONSTITUENT	903.38	RYZNAR STABILITY INDEX	6.90
LAB SPEC.COND.(MICROMHOS/CM)	1115.	LANGLIER SATURATION INDEX	0.33

PARAMETER	VALUE	PARAMETER	VALUE
TEMPERATURE, AIR (C)	30.0 F	CNDUCTVY,FIELD MICROMHOS	1151.
FIELD PH	6.80	ALKALINITY,FLD(AS CACO3)	205.00
ALUMINUM, DISS (MG/L-AL)	<.03	NICKEL,DISS (MG/L AS NI)	<.01
SILVER,DISS (MG/L AS AG)	<.002	LEAD,DISS (MG/L AS PB)	<.04
BORON ,DISS (MG/L AS B)	.10	STRONTIUM,DISS (MG/L-SR)	.86
CADMIUM,DISS(MG/L AS CD)	<.002	TITANIUM DIS(MG/L AS TI)	.010
CHROMIUM, DISS (MG/L-CR)	<.002	VANADIUM,DISS(MG/L AS V)	.002
COPPER,DISS (MG/L AS CU)	.008	ZINC,DISS (MG/L AS ZN)	.015
LITHIUM,DISS(MG/L AS LI)	.053	ZIRCONIUM DIS(MG/L AS ZR	<.003
MOLYBDENUM,DISS(MG/L-MO)	<.02	ARSENIC,DISS(UG/L AS AS)	.3

REMARKS: CLEAR
FILTER A LITTLE YELLOWISH, VERY FINE SILT ON FILTER AND SAND

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L = MILLIEQUIVELENTS PER LITER. FT = FEET, MT = METERS. (M) = MEASURED, (E) = ESTIMATED, (R) = REPORTED. TR = TOTAL RECOVERABLE. TOT = TOTAL.

OW WA S2 WI OW FW AT OTHER

OTHER AVAILABLE DATA
OTHER FILE NUMBERS:

PROJECT:		COST:	
LAST EDIT DATE:	02-FEB-83	BY:	TP *BCG
PROCESSING PROGRAM:	F1730P V2 (11/3/81)	PRINTED:	27-MAY-83

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
36.3	55.0	7.2	1.5	3.0	67.9	29.2	0.0

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: 8300002

MONTANA BUREAU OF MINES AND GEOLOGY — WATER QUALITY ANALYSIS
BUTTE, MONTANA 59701 (406)496 4101 — LAB NO. 8300003

STATE	MONTANA	COUNTY	CASCADE
LATITUDE LONGITUDE	47D24'21"N 111D09'16"W	SITE LOCATION	19N 04E 13 AAAD
UTM COORDINATES	? N C	MBMG SITE	
TOPOGRAPHIC MAP	SOUTHEAST GREAT FALLS 7.1	STATION ID	472421111091601
GEOLOGIC SOURCE	330MDSN* * *	SAMPLE SOURCE	WELL
DRAINAGE BASIN	BB	LAND SURFACE ALTITUDE	3410. FT 10
AGENCY + SAMPLER	MBMG*HRM	SUSTAINED YIELD	
BOTTLE NUMBER	MINERAV	YIELD MEAS METHOD	
DATE SAMPLED	29-DEC-82	TOTAL DEPTH OF WELL	170.0 FT (R)
TIME SAMPLED	15:00 HOURS	SWL ABOVE( ) OR BELOW GS	
LAB + ANALYST	MBMG*ENA	CASING DIAMETER	7 IN (R)
DATE ANALYZED	19 JAN 83	CASING TYPE	IRON
SAMPLE HANDLING		COMPLETION TYPE	12*
METHOD SAMPLED	PUMPED	PERFORATION INTERVAL	
WATER USE	DOMESTIC		

SAMPLING SITE M NAVULA, STAR RT, SAND COULEE, N OF 7 SIDING
GEOLOGIC SOURCE MADISON GROUP OR LIMESTONE

	MG/L	MEQ/L		MG/L	MEQ/L
CALCIUM (CA)	118.	5.89	BICARBONATE (HCO3)	240.1	3.93
MAGNESIUM (MG)	36.0	2.96	CARBONATE (CO3)	0.	
SODIUM (NA)	16.9	0.74	CHLORIDE (CL)	6.0	0.17
POTASSIUM (K)	3.4	0.09	SULFATE (SO4)	250.	5.25
IRON (FE)	.006	0.00	NITRATE (AS N)	3.85	0.27
MANGANESE (MN)	.004	0.00	FLUORIDE (F)	.32	0.02
SILICA (SIO2)	14.7		PHOSPHATE TOT (AS P)		
TOTAL CATIONS		9.67	TOTAL ANIONS		9.61

STANDARD DEVIATION OF ANION-CATION BALANCE (SIGMA) 0.12

LABORATORY PH	7.4	TOTAL HARDNESS AS CACO3	442.82
FIELD WATER TEMPERATURE	3.7 C	TOTAL ALKALINITY AS CACO3	196.92
CALCULATED DISSOLVED SOLIDS	569.46	SODIUM ABSORPTION RATIO	0.35
SUM OF DISS. CONSTITUENT	891.20	RYZNAR STABILITY INDEX	6.87
LAB SPEC.COND.(MICROMHOS/CM)	829.3	LANGLIER SATURATION INDEX	0.27

PARAMETER	VALUE	PARAMETER	VALUE
TEMPERATURE, AIR (C)	25. F	CNDUCTVY,FIELD MICROMHOS	778.
FIELD PH	8.10	ALKALINITY,FLD(AS CACO3)	200.
ALUMINUM, DISS (MG/L AL)	.03	NICKEL,DISS (MG/L AS NI)	.02
SILVER,DISS (MG/L AS AG)	<.002	LEAD,DISS (MG/L AS PB)	<.04
BORON ,DISS (MG/L AS B)	.10	STRONTIUM,DISS (MG/L-SR)	.67
CADMIUM,DISS(MG/L AS CD)	.003	TITANIUM DIS(MG/L AS TI)	.014
CHROMIUM, DISS (MG/L-CR)	<.002	VANADIUM,DISS(MG/L AS V)	.001
COPPER,DISS (MG/L AS CU)	.014	ZINC,DISS (MG/L AS ZN)	.49
LITHIUM,DISS(MG/L AS LI)	.016	ZIRCONIUM DIS(MG/L AS ZR	.003
MOLYBDENUM,DISS(MG/L-MO)	<.02	ARSENIC,DISS(UG/L AS AS)	.1

REMARKS: INITIAL TAP WATER RUSTY COLOR FOR 5 SEC, FILTER ALSO RUST COLORED

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L = MILLIEQUIVELENTS PER LITER, FT = FEET, MT = METERS, (M) = MEASURED, (E) = ESTIMATED, (R) = REPORTED. TR = TOTAL RECOVERABLE. TOT = TOTAL.

	QW	NA	SO	MI	OW	PW	AT	OTHER
OTHER AVAILABLE DATA		Y						

OTHER FILE NUMBERS:

PROJECT: — COST:
LAST EDIT DATE: 01-FEB-83 — BY: TP *BCS
PROCESSING PROGRAM: F1730P V2 (11/3/81) — PRINTED: 27 MAY 83

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
60.9	30.6	7.6	0.9	1.8	56.1	42.1	0.0

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: 8300003
Reads

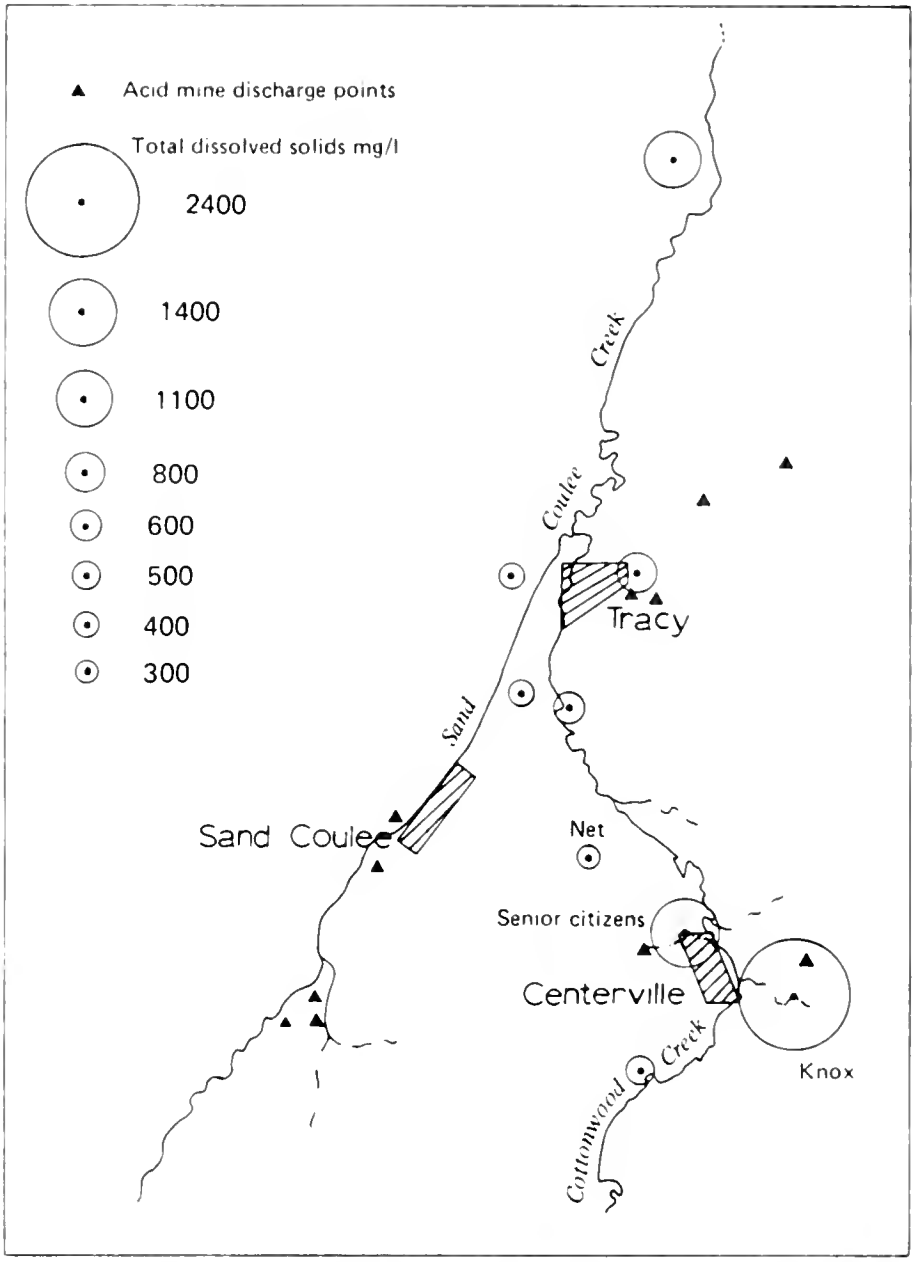


Figure C-3. Location of acid discharge points and total dissolved solids in Madison wells.

APPENDIX D

SURFACE WATER DATA

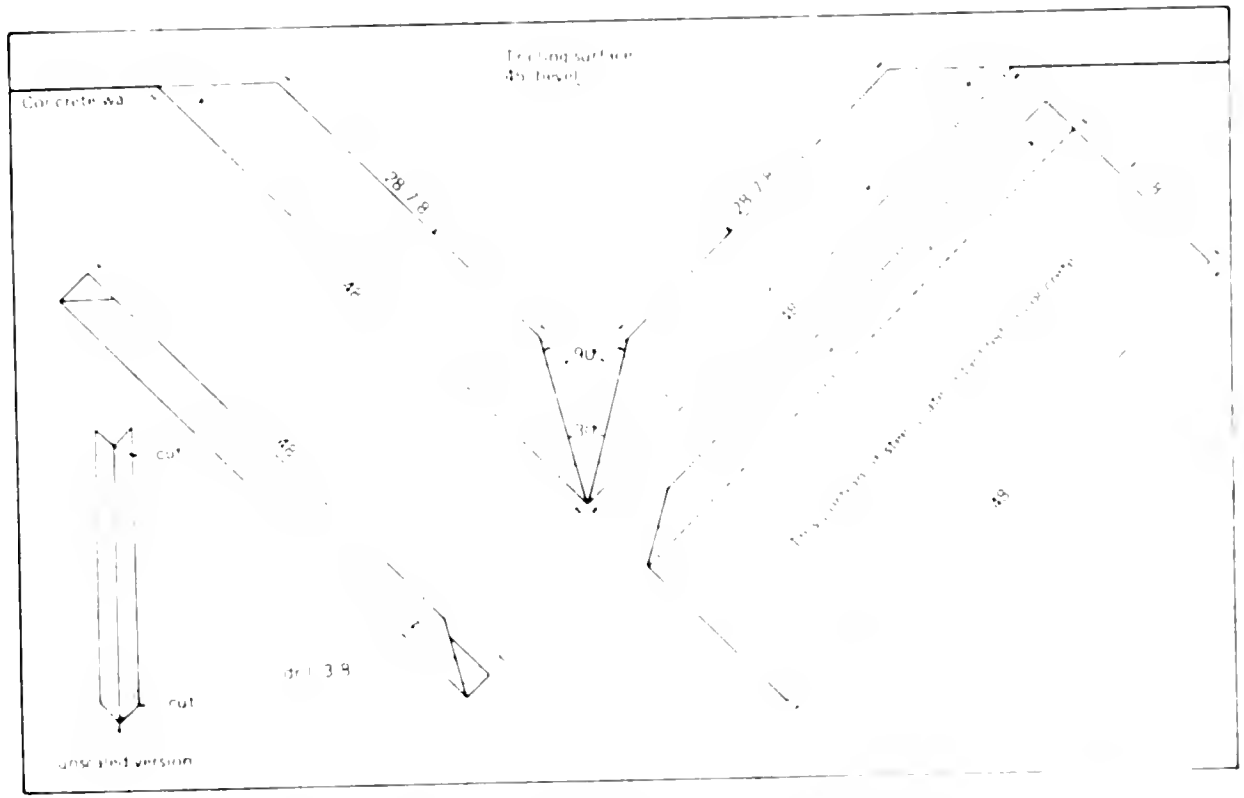


FIGURE D 1 Diagram of weir at gaging stations AF01, CF02, and CF03

The discharge rating equations are

For gage heights (g, h) $<$ 1.12 ft $Q(ft^3/s) = 0.6672 \cdot (g, h)^{2.5}$

For gage heights (g, h) $\geq$ 1.12 ft $Q(ft^3/s) = [2.49 \cdot ((g, h) - 0.8176)^{2.48}]^{1} + 0.7545$

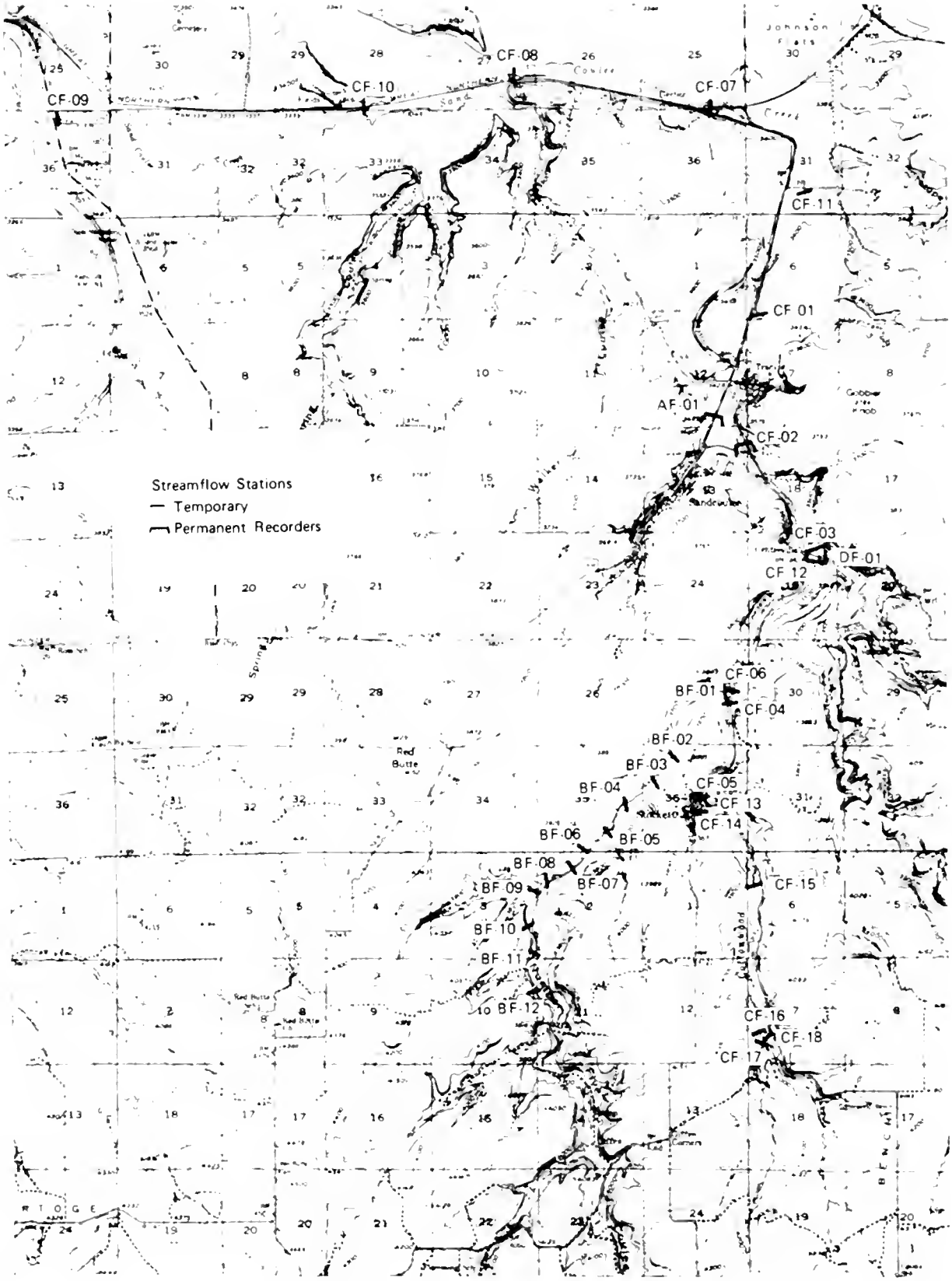


Figure D-2. Streamflow stations established for seepage profiling.

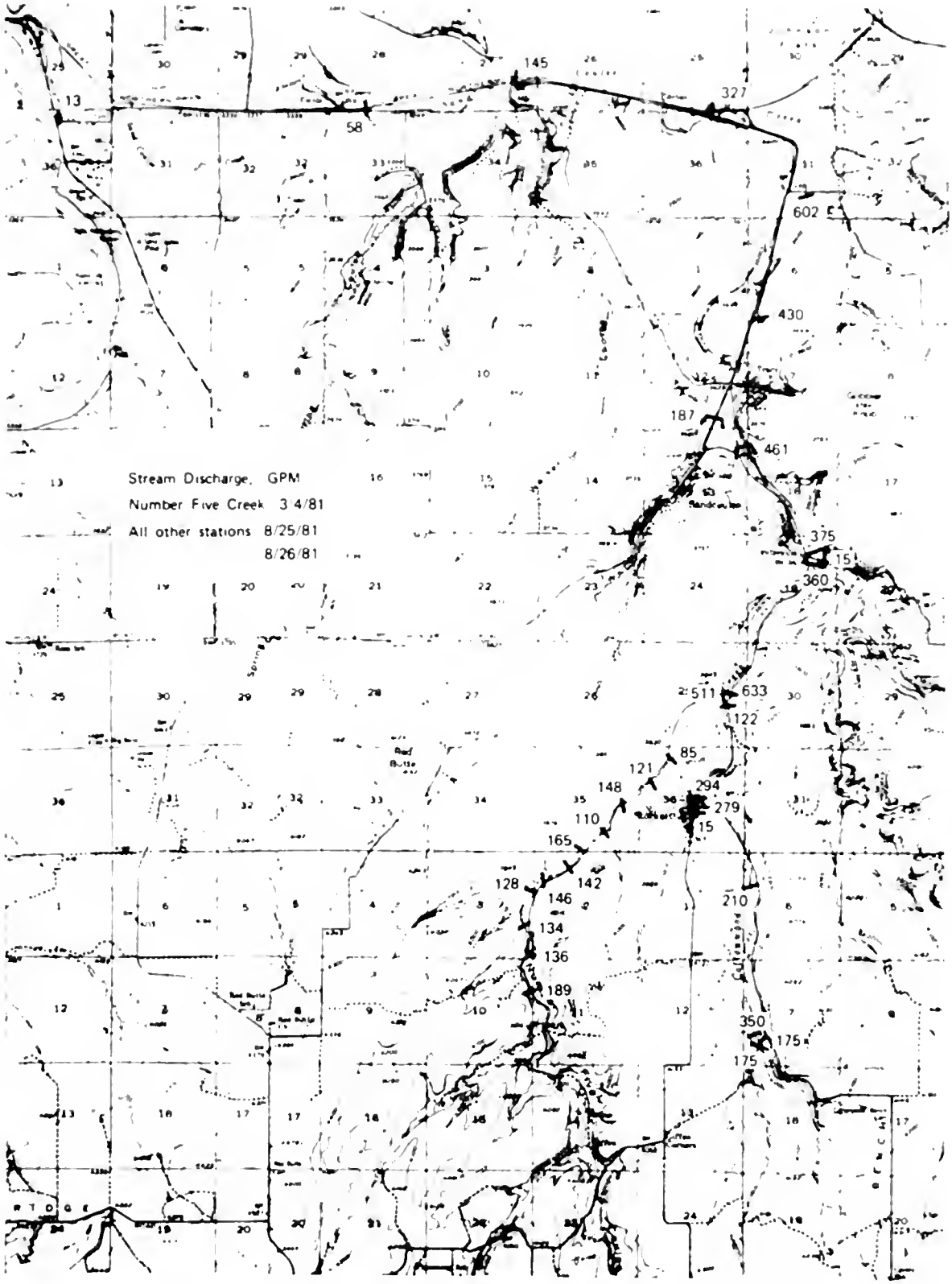


Figure D-3. Streamflow quantities measured in 1981.

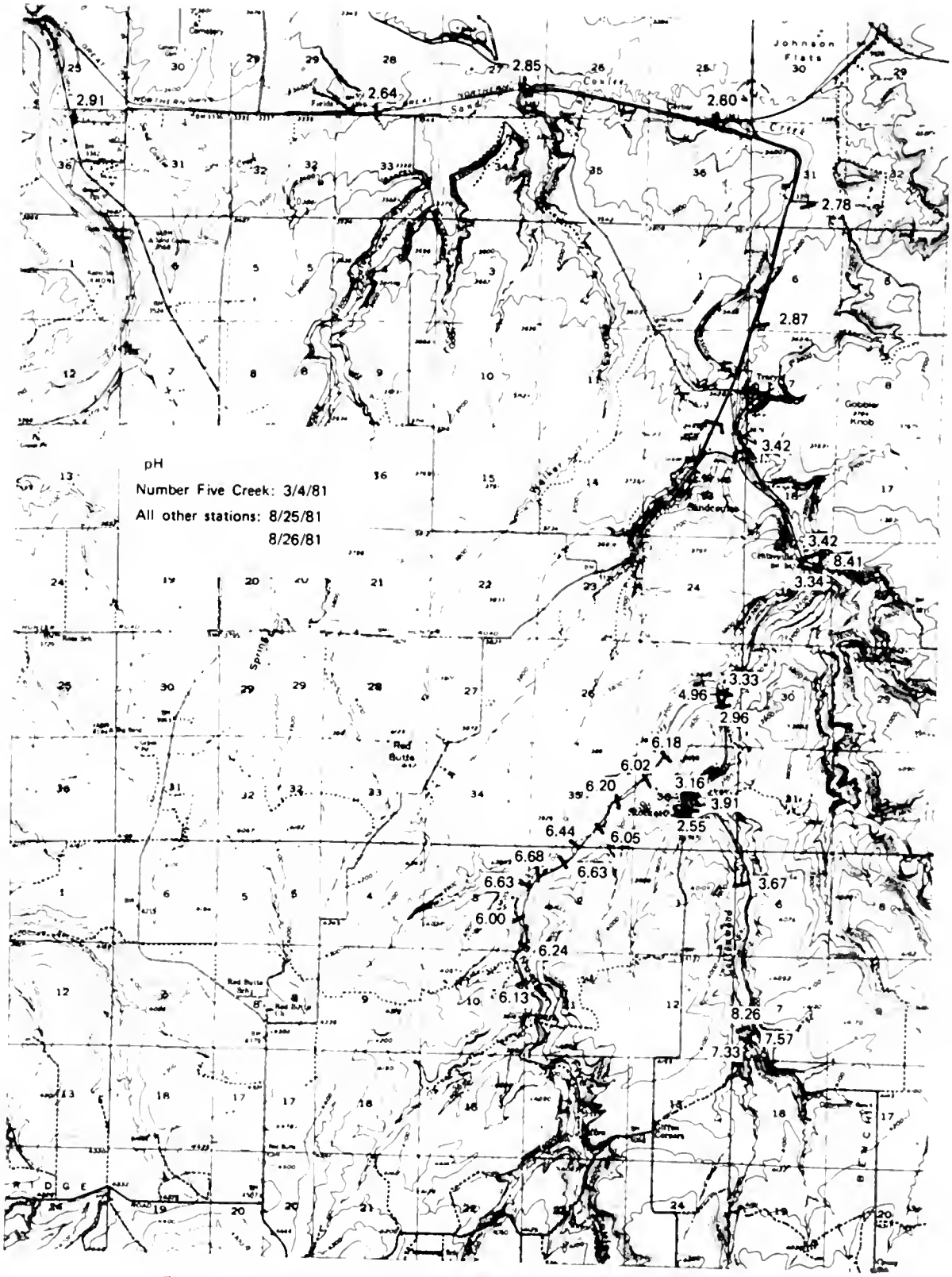


Figure D-4. Measurements of pH at the time of streamflow measurement.

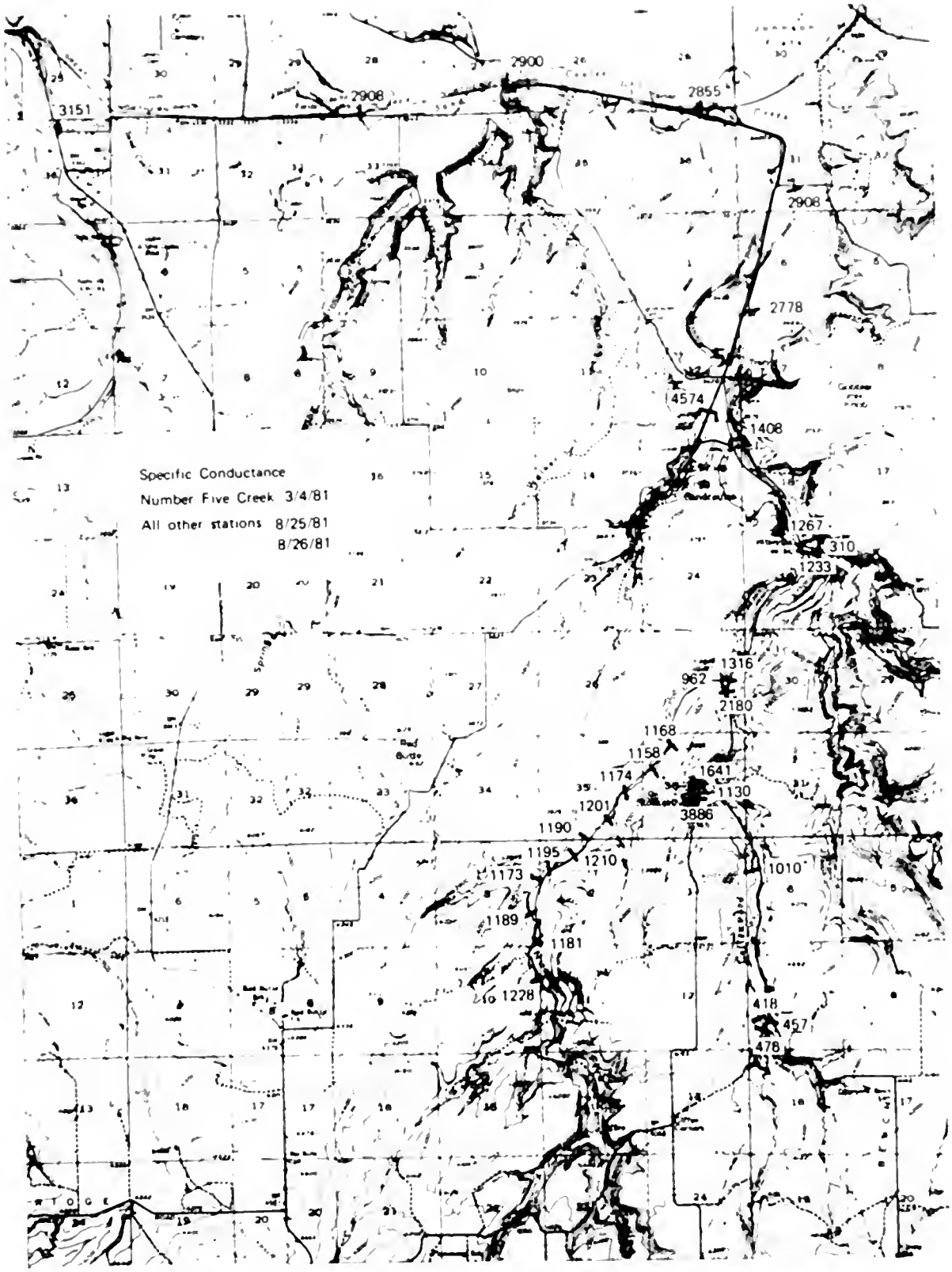


Figure D-5. Specific conductance values at the time of streamflow measurement.

D-6

STREAM WATER QUALITY DATA

MONTANA BUREAU OF MINES AND GEOLOGY — WATER QUALITY ANALYSIS
BUTTE, MONTANA 59701 (406)496-4101 — LAB NO. 8101005

STATE MONTANA — COUNTY CASCADE
LATITUDE LONGITUDE 47°01'23"N 111°02'10"W — SITE LOCATION 10N 04E 13 ABAD
UTM COORDINATES 12U N5250120 E487295 — MBMG SITE AE 01
TOPOGRAPHIC MAP SOUTHEAST GREAT FALLS 7.5 — STATION ID 470123111024201
GEOLOGIC SOURCE * * * SAMPLE SOURCE STREAM
DRAINAGE BASIN MR — LAND SURFACE ALTITUDE 3435.
AGENCY & SAMPLER MBMG*AEM — WATER FLOW RATE 502. GPM
BOTTLE NUMBER AE 01 — FLOW MEAS METHOD WEIR
DATE SAMPLED 15 JUN 81 — STAFF GAGE 1.24
TIME SAMPLED 16:00 HOURS — STREAM STAGE
LAB & ANALYST MBMG*ENA — DEPTH TO SAMPLE
DATE ANALYZED — TOTAL DEPTH OF WATER
SAMPLE HANDLING 4220 — STREAM WIDTH
METHOD SAMPLED GRAB

WATER USE UNUSED

SAMPLING SITE SAND COULEE MINING DISTRICT*NO NAME CREEK
DRAINAGE BASIN MISSOURI RIVER BETWEEN MARIAS RIVER AND LITTLE PRICKLY PE

	MG/L	MEQ/L			MG/L	MEQ/L
CALCIUM (CA)	164.	8.18	BICARBONATE	(HCO3)	0.	
MAGNESIUM (MG)	132.	11.22	CARBONATE	(CO3)	0.	
SODIUM (NA)	23.4	1.02	CHLORIDE	(CL)	7.5	0.21
POTASSIUM (K)	3.3	0.08	SULFATE	(SO4)	3240.	33.63
IRON (FE)	104.	22.78	NITRATE	(AS N)	2.12	0.15
MANGANESE (MN)	1.46	0.05	FLUORIDE	(F)	7.14	0.38
SILICA (SIO2)	55.4		PHOSPHATE TOT	(AS P)		
TOTAL CATIONS		43.39	TOTAL ANIONS			32.77

STANDARD DEVIATION OF ANION CATION BALANCE (SIGMA)

LABORATORY PH	2.41	TOTAL HARDNESS AS CACO3	924.40
FIELD WATER TEMPERATURE	23.9	TOTAL ALKALINITY AS CACO3	
CALCULATED DISSOLVED SOLIDS		SODIUM ABSORPTION RATIO	0.33
SUM OF DISS. CONSTITUENT		RYZNAR STABILITY INDEX	
LAB SPEC.COND.(MICROMHOS/CM)	4243.	LANGLIER SATURATION INDEX	

PARAMETER	VALUE	PARAMETER	VALUE
TEMPERATURE, AIR (C)	25.	CNDUCTVY,FIELD MICROMHOS	3240.
FIELD PH	3.00	ALUMINUM, DISS (MG/L AL)	242.
NICKEL,DISS (MG/L AS NI)	1.91	SILVER,DISS (MG/L AS AG)	.002
LEAD,DISS (MG/L AS PB)	.04	BORON ,DISS (MG/L AS B)	.12
STRONTIUM,DISS (MG/L SR)	1.09	CADMIUM,DISS(MG/L AS CD)	.011
TITANIUM DIS(MG/L AS TI)	.014	CHROMIUM, DISS (MG/L CR)	.012
VANADIUM,DISS(MG/L AS V)	.044	COPPER,DISS (MG/L AS CU)	.013
LITHIUM,DISS(MG/L AS LI)	.52	MOLYBDENUM,DISS(MG/L MO)	.02
IRON,TR (MG/L AS FE)	421.	SELENIUM,TR (UG/L AS SE)	.8
ALUMINUM,TR (MG/L AS AL)	238.	ACIDITY,TOT(MG/L CACO3)	3000.
ZINC,DISS (MG/L AS ZN)	7.72	ZIRCONIUM DIS(MG/L AS ZR	.003

REMARKS: WATER MUDDY AND RUSTY COLOR
NO NAME CREEK GAGING STATION AE-01
LAB: RH 30.88 MG/L GIVES 30.25 MEQ. CATIONS GIVES 1.31 SIGMA

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L = MILLIEQUIVELENTS PER LITER, FT = FEET, MI = METERS, (M) = MEASURED, (E) = ESTIMATED, (R) = REPORTED, TR = TOTAL RECOVERABLE, TOT = TOTAL.

GW WA SO WI OW PW AT OTHER

OTHER AVAILABLE DATA
OTHER FILE NUMBERS:

PROJECT: — COST:
LAST EDIT DATE: 12 FEB 82 — BY: JO *JHS
PROCESSING PROGRAM: F1230F V2 (11/3/81) — PRINTED: 22 MAY 83

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
39.8	54.8	5.0	0.4	0.3	99.7	0.0	0.0

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: 8101005

MONTANA BUREAU OF MINES AND GEOLOGY
BUTTE,MONTANA 59701 (406)496-4101

WATER QUALITY ANALYSIS
LAB NO. 8101511

STATE	MONTANA	COUNTY	CASCADE
LATITUDE-LONGITUDE	47D23'23"N 111D08'24"W	SITE LOCATION	19N 5E 19 AACA
UTM COORDINATES	Z N E	MBMG SITE	CF-03
TOPOGRAPHIC MAP	SOUTHEAST GREAT FALLS 7.1	STATION ID	472323111082401
GEOLOGIC SOURCE	* * *	SAMPLE SOURCE	STREAM
DRAINAGE BASIN	BD	LAND SURFACE ALTITUDE	3464. FT < 1
AGENCY & SAMPLER	MBMG*JLS	WATER FLOW RATE	375. GPM
BOTTLE NUMBER	CF-03	FLOW MEAS METHOD	WEIR
DATE SAMPLED	22-AUG-81	STAFF GAGE	
TIME SAMPLED	11:00 HOURS	STREAM STAGE	
LAB & ANALYST	MBMG*FNA	DEPTH TO SAMPLE	
DATE ANALYZED		TOTAL DEPTH OF WATER	1.1 FT (M)
SAMPLE HANDLING	4220	STREAM WIDTH	
METHOD SAMPLED	GRAB		

WATER USE UNUSED

SAMPLING SITE SAND COULEE CREEK AT CENTERVILLE SCHOOL *
DRAINAGE BASIN MISSOURI RIVER BETWEEN MARIAS RIVER AND LITTLE PRICKLY P

		MG/L	MEQ/L			MG/L	MEQ/L
CALCIUM	(CA)	145.	7.24	BICARBONATE	(HCO3)	.0	
MAGNESIUM	(MG)	58.0	4.77	CARBONATE	(CO3)	.0	
SODIUM	(NA)	15.2	0.66	CHLORIDE	(CL)	6.8	0.19
POTASSIUM	(K)	4.9	0.13	SULFATE	(SO4)	857.	17.84
IRON	(FE)	10.1	0.54	NITRATE	(AS N)	1.95	0.14
MANGANESE	(MN)	.89	0.03	FLUORIDE	(F)	1.43	0.08
SILICA	(SIO2)	16.6		PHOSPHATE TOT	(AS P)		
TOTAL CATIONS			13.37	TOTAL ANIONS			18.25

STANDARD DEVIATION OF ANION-CATION BALANCE (SIGMA)

LABORATORY PH	3.35	TOTAL HARDNESS AS CACO3	600.79
FIELD WATER TEMPERATURE	19.6 C	TOTAL ALKALINITY AS CACO3	
CALCULATED DISSOLVED SOLIDS		SODIUM ADSORPTION RATIO	0.27
SUM OF DISS. CONSTITUENT		RYZNAR STABILITY INDEX	
LAB SPEC.COND.(MICROMHOS/CM)	1567.	LANGLIER SATURATION INDEX	

PARAMETER	VALUE	PARAMETER	VALUE
TEMPERATURE, AIR (C)	22. C	CNDUCTVY,FIELD MICROMHOS	1267.
FIELD PH	3.42	ALUMINUM, DISS (MG/L AL)	39.6
NICKEL,DISS (MG/L AS NI)	.90	SILVER,DISS (MG/L AS AG)	<.002
LEAD,DISS (MG/L AS PB)	<.04	BORON ,DISS (MG/L AS B)	.05
STRONTIUM,DISS (MG/L-SR)	.42	CADMIUM,DISS(MG/L AS CD)	.016
TITANIUM DIS(MG/L AS TI)	.027	CHROMIUM, DISS (MG/L-CR)	.010
VANADIUM,DISS(MG/L AS V)	.012	COPPER,DISS (MG/L AS CU)	.000
ZINC,DISS (MG/L AS ZN)	3.77	LITHIUM,DISS(MG/L AS LI)	.005
ZIRCONIUM DIS(MG/L AS ZR	.007	MOLYBDENUM,DISS(MG/L-MO)	.03
SELENIUM, DISS (UG/L-SE)	.7	ACIDITY,TOT(MG/L-CACO3)	313.

REMARKS: WATER IS BRIGHT ORANGE * ABUNDANT FE-HYDROXIDE FLOCCULENT *
MBMG GAGING STATION CF-03 * 1 FILTER USED * FRESH FLOC BELOW DE-01
INFLOW *
LAB: PH 6.30 MG/L GIVES 19.0 MEQ CATIONS GIVES -2.01 SIGMA

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L =
MILLIEQUIVELENTS PER LITER, FT = FEET, MT = METERS, (M) = MEASURED, (E) =
ESTIMATED, (R) = REPORTED, TR = TOTAL RECOVERABLE, TOT = TOTAL.

	GW	WA	SD	WI	GW	PW	AT	OTHER
OTHER AVAILABLE DATA								
OTHER FILE NUMBERS:								

PROJECT:		COST:	
LAST EDIT DATE:	19-FEB-82	BY:	TP *JKS
PROCESSING PROGRAM:	F1730P V2 (11/3/81)	PRINTED:	27 MAY-83

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
56.6	37.3	5.2	1.0	1.1	98.9	0.0	0.0

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: 8101511 D-7

MONTANA BUREAU OF MINES AND GEOLOGY — WATER QUALITY ANALYSIS
BUTTE, MONTANA 59701 (406)496 4101 — LAB NO. 81815.2

STATE MONTANA — COUNTY CASCADE
LATITUDE LONGITUDE 47D22'14"N [illegible] — SITE LOCATION SW [illegible]
UTM COORDINATES Z N E — MBMG SITE CC [illegible]
TOPOGRAPHIC MAP STOCKETT 7 1/2 — STATION [illegible]
GEOLOGIC SOURCE * * SAMPLE SOURCE STREAM
DRAINAGE BASIN DB LAND SURFACE ALTITUDE [illegible]
AGENCY & SAMPLER MBMG*JJD WATER FLOW RATE [illegible]
BOTTLE NUMBER CF 06 FLOW MEAS METHOD WEIR
DATE SAMPLED 29 AUG 81 STAGE GAGE
TIME SAMPLED 10:00 HOURS SIPHON GAGE
LAB & ANALYST MBMG*ENA DEPTH TO SAMPLE
DATE ANALYZED TOTAL DEPTH OF WATER
SAMPLE HANDLING 4220 STREAM WIDTH
METHOD SAMPLED GRAB

WATER USE UNUSED

SAMPLING SITE COTTONWOOD CR BELOW CONFLUENCE W/#5 CREEK *
DRAINAGE BASIN MISSOURI RIVER BETWEEN MARIAS RIVER AND [illegible]

	MG/L	MEQ/L			MG/L	MEQ/L
CALCIUM (CA)	139.	6.94	BICARBONATE	(HCO3)	0	
MAGNESIUM (MG)	57.8	4.75	CARBONATE	(CO3)	0	
SODIUM (NA)	15.4	0.67	CHLORIDE	(CL)	2.7	.08
POTASSIUM (K)	4.8	0.12	SULFATE	(SO4)	850	17.70
IRON (FE)	30.5	1.64	NITRATE	(AS N)	2.12	0.15
MANGANESE (MN)	.83	0.03	FLUORIDE	(F)	1.33	0.07
SILICA (SIO2)	15.2		PHOSPHATE TOT	(AS P)		

TOTAL CATIONS 14.15 — TOTAL ANIONS 18.12

STANDARD DEVIATION OF ANION CATION BALANCE (SIGMA)

LABORATORY PH	3.64	TOTAL HARDNESS AS CACO3	584.00
FIELD WATER TEMPERATURE	17.0 C	TOTAL ALKALINITY AS CACO3	
CALCULATED DISSOLVED SOLIDS		SODIUM ADSORPTION RATIO	0.20
SUM OF DISS. CONSTITUENT		RYZNAR STABILITY INDEX	
LAB SPEC.COND.(MICROMHOS/CM)	1499.	LANGLIER SATURATION INDEX	

PARAMETER	VALUE	PARAMETER	VALUE
TEMPERATURE, AIR (C)	18. C	CNDUCTVY,FIELD MICROMHOS	1316.
FIELD PH	3.33	ALUMINUM, DISS (MG/L AL)	33.7
NICKEL,DISS (MG/L AS NI)	.87	SILVER,DISS (MG/L AS AG)	.002
LEAD,DISS (MG/L AS PB)	.04	BORON ,DISS (MG/L AS B)	.06
STRONTIUM,DISS (MG/L SR)	.40	CADMIUM,DISS(MG/L AS CD)	.012
TITANIUM DIS(MG/L AS TI)	.021	CHROMIUM, DISS (MG/L CR)	.009
VANADIUM,DISS(MG/L AS V)	.004	COPPER,DISS (MG/L AS CU)	.066
ZINC,DISS (MG/L AS ZN)	3.84	LITHIUM,DISS(MG/L AS LI)	.083
ZIRCONIUM DIS(MG/L AS ZR	.008	MOLYBDENUM,DISS(MG/L MO)	.03
SELENIUM, DISS (UG/L SE)	.7	ACIDITY,TOT(MG/L CACO3)	220.

REMARKS: WATER IS BRIGHT ORANGE * ABUNDANT FE HYDROXIDE FLOCCULENT *
NO. FIVE CREEK FLOW 511 GPM, PH 4.96, S.C. 962 * COTTONWOOD CREEK
UPSTREAM FLOW 122 GPM, PH 2.96, S.C. 2180 *
LAB: AT 5.85 MG/L GIVES 18.3 MEQ CATIONS GIVES .43 SIGMA

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L = MILLIEQUIVALENTS PER LITER, FT - FEET, MI - METERS, (M) = MEASURED, (E) = ESTIMATED, (R) = REPORTED, TR = TOTAL RECOVERABLE, TOT = TOTAL.

GW WA SO WI QW PW AT OTHER

OTHER AVAILABLE DATA
OTHER FILE NUMBERS:

PROJECT: — COST:
LAST EDIT DATE: 12 SEP 82 — BY: ID *JNS
PROCESSING PROGRAM: I1230P V2 (11/3/81) PRINTED: 27 MAY 83

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
55.6	38.1	5.4	1.0	1.2	98.8	0.0	0.0

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: [illegible]

MONTANA BUREAU OF MINES AND GEOLOGY
BUTTE, MONTANA 59701 (406)496-4101

WATER QUALITY ANALYSIS
LAB NO. 81G1513

STATE	MONTANA	COUNTY	CASCADE
LATITUDE LONGITUDE	47D26'59"N 111D09'24"W	SITE LOCATION	20N 5E 36 AAA
UTM COORDINATES	Z N E	MBMG SITE	CF-07
TOPOGRAPHIC MAP	SOUTHEAST GREAT FALLS 7.1	STATION ID	472659111092401
GEOLOGIC SOURCE	* * *	SAMPLE SOURCE	STREAM
DRAINAGE BASIN	BB	LAND SURFACE ALTITUDE	3302. FT < 10
AGENCY & SAMPLER	MBMG*JLS	WATER FLOW RATE	327. GPM
BOTTLE NUMBER	CF-07	FLOW MEAS METHOD	WEIR
DATE SAMPLED	28 AUG 81	STAFF GAGE	
TIME SAMPLED	11:00 HOURS	STREAM STAGE	
LAB & ANALYST	MBMG*ENA	DEPTH TO SAMPLE	
DATE ANALYZED		TOTAL DEPTH OF WATER	0.6 FT (M)
SAMPLE HANDLING	4220	STREAM WIDTH	
METHOD SAMPLED	GRAB		

WATER USE UNUSED

SAMPLING SITE SAND COULEE CREEK .5 MI E OF GERBER SIDING
DRAINAGE BASIN MISSOURI RIVER BETWEEN MARIAS RIVER AND LITTLE PRICKLY PE

	MG/L	MEQ/L		MG/L	MEQ/L
CALCIUM (CA)	160.	7.98	BICARBONATE (HCO3)	.0	
MAGNESIUM (MG)	91.8	7.55	CARBONATE (CO3)	.0	
SODIUM (NA)	12.0	0.74	CHLORIDE (CL)	11.0	0.31
POTASSIUM (K)	3.4	0.09	SULFATE (SO4)	2300.	47.89
IRON (FE)	196.	10.53	NITRATE (AS N)	1.07	0.08
MANGANESE (MN)	1.61	0.06	FLUORIDE (F)	5.75	0.30
SILICA (SIO2)	14.7		PHOSPHATE TOT (AS P)		
TOTAL CATIONS		26.95	TOTAL ANIONS		48.58

STANDARD DEVIATION OF ANION-CATION BALANCE (SIGMA)

LABORATORY PH	2.89	TOTAL HARDNESS AS CACO3	777.37
FIELD WATER TEMPERATURE	17.0 C	TOTAL ALKALINITY AS CACO3	
CALCULATED DISSOLVED SOLIDS		SODIUM ADSORPTION RATIO	0.27
SUM OF DISS. CONSTITUENT		RYZNAR STABILITY INDEX	
LAB SPEC.COND.(MICROMHOS/CM)	3306.	LANGLIER SATURATION INDEX	

PARAMETER	VALUE	PARAMETER	VALUE
TEMPERATURE, AIR (C)	18.0 C	CNDUCTVY,FIELD MICROMHOS	2855.
FIELD PH	2.6	ALUMINUM, DISS (MG/L AL)	203.
NICKEL,DISS (MG/L AS NI)	2.18	SILVER,DISS (MG/L AS AG)	.005
LEAD,DISS (MG/L AS PB)	<.04	BORON ,DISS (MG/L AS B)	.14
STRONTIUM,DISS (MG/L SR)	.66	CADMIUM,DISS(MG/L AS CD)	.049
TITANIUM DIS(MG/L AS TI)	.32	CHROMIUM, DISS (MG/L-CR)	.10
VANADIUM,DISS(MG/L AS V)	.015	COPPER,DISS (MG/L AS CU)	.19
ZINC,DISS (MG/L AS ZN)	9.19	LITHIUM,DISS(MG/L AS LI)	.28
ZIRCONIUM DIS(MG/L AS ZR	.019	MOLYBDENUM,DISS(MG/L-MO)	.08
SELENIUM, DISS (UG/L SE)	.7	ACIDITY,TOT(MG/L CACO3)	1040.

REMARKS: WATER IS RED BROWN * LARGE PARTICULATE HYDROXIDE FLOCCULENT *
LAB: NI 37.96 MG/L GIVES 53.11 MEQ CATIONS GIVES 5.13 SIGMA

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L = MILLIEQUIVALENTS PER LITER, FT = FEET, MT = METERS, (M) = MEASURED, (E) = ESTIMATED, (R) = REPORTED, TR = TOTAL RECOVERABLE, TOT = TOTAL.

GW WA SS WI SW PW AT OTHER

OTHER AVAILABLE DATA
OTHER FILE NUMBERS:

PROJECT: COST:
LAST EDIT DATE: 19-FEB 82 BY: TO *JKS
PROCESSING PROGRAM: F1730P V2 (11/3/81) PRINTED: 27 MAY 83

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
40.2	46.2	4.5	0.5	0.6	99.1	0.0	0.0

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: B1G1513)-9

MONTANA BUREAU OF MINES AND GEOLOGY — WATER QUALITY ANALYSIS
BUTTE, MONTANA 59701 (406)496 4101 — LAB NO. 0101514

STATE MONTANA — COUNTY CASCADE
LATITUDE LONGITUDE 47D26'58"N 111D17'38"W — SITE LOCATION SEN 3E 24 ABBC (
UTM COORDINATES Z N E — MBMG SITE CF-02
TOPOGRAPHIC MAP SOUTHWEST GREAT FALLS 7.1 — STATION ID 4726581111738001
GEOLOGIC SOURCE * * * — SAMPLE SOURCE STREAM
DRAINAGE BASIN MR — LAND SURFACE ALTITUDE
AGENCY & SAMPLER MBMG*JJD — WATER FLOW RATE 13. GPM
BOTTLE NUMBER CF-02 — FLOW MEAS METHOD WEIR
DATE SAMPLED 26-AUG 81 — STAGE GAGE
TIME SAMPLED 16:00 HOURS — STREAM STAGE LOW FLOW
LAB & ANALYST MBMG*ENA — DEPTH TO SAMPLE
DATE ANALYZED — TOTAL DEPTH OF WATER .1 FT (M)
SAMPLE HANDLING 4220 — STREAM WIDTH 10. FT
METHOD SAMPLED GRAB

WATER USE UNUSED

SAMPLING SITE SAND COULEE CR*BRIDGE AT MISSOURI RIVER FR
DRAINAGE BASIN MISSOURI RIVER BETWEEN MARIAS RIVER AND LITTLE PRICKLY PE

		MG/L	MEQ/L			MG/L	MEQ/L
CALCIUM	(CA)	181.	9.03	BICARBONATE	(HCO3)	.0	
MAGNESIUM	(MG)	86.3	7.10	CARBONATE	(CO3)	.0	
SODIUM	(NA)	38.8	1.69	CHLORIDE	(CL)	22.6	0.64
POTASSIUM	(K)	7.9	0.20	SULFATE	(SO4)	1490.	31.02
IRON	(FE)	15.7	0.84	NITRATE	(AS N)	.74	0.05
MANGANESE	(MN)	1.79	0.07	FLUORIDE	(F)	3.41	0.18
SILICA	(SIO2)	27.1		PHOSPHATE TOT	(AS P)		

TOTAL CATIONS 18.93 — TOTAL ANIONS 31.89

STANDARD DEVIATION OF ANION CATION BALANCE (SIGMA)

LABORATORY PH 3.27 — TOTAL HARDNESS AS CACO3 807.17
FIELD WATER TEMPERATURE 13.2 C — TOTAL ALKALINITY AS CACO3
CALCULATED DISSOLVED SOLIDS — SODIUM ADSORPTION RATIO 0.59
SUM OF DISS. CONSTITUENT — RYZNAR STABILITY INDEX
LAB SPEC.COND.(MICROMHOS/CM) 2348. — LANGLIER SATURATION INDEX

PARAMETER	VALUE	PARAMETER	VALUE
TEMPERATURE, AIR (C)	25. C	CNDUCTVY,FIELD MICROMHOS	3151.
FIELD PH	2.91	ALUMINUM, DISS (MG/L AL)	117.
NICKEL,DISS (MG/L AS NI)	1.39	SILVER,DISS (MG/L AS AG)	<.002
LEAD,DISS (MG/L AS PB)	<.04	BORON ,DISS (MG/L AS B)	.12
STRONTIUM,DISS (MG/L SR)	.79	CADMIUM,DISS(MG/L AS CD)	.021
TITANIUM DIS(MG/L AS TI)	.033	CHROMIUM, DISS (MG/L CR)	.032
VANADIUM,DISS(MG/L AS V)	.006	COPPER,DISS (MG/L AS CU)	.12
ZINC,DISS (MG/L AS ZN)	5.60	LITHIUM,DISS(MG/L AS LI)	.10
ZIRCONIUM DIS(MG/L AS ZR	<.003	MOLYBDENUM,DISS(MG/L MO)	.06
SELENIUM, DISS (UG/L SE)	.6	ACIDITY,TOT(MG/L CACO3)	810.

REMARKS: WATER IS TURBID, MURKY, ALGAE-RICH * LARGE FLOCCULENTS OF ORANGE FE-HYDROXIDE PRECIPITATE * BANKS & BED RICH IN FE-HYDROXIDE MUD DEPOSITED AFTER MAY FLOOD * HIGH WATER @ 5.4 ABOVE CHANNEL *
LAB: CA 16.31 MG/L GIVES 34.21 MEQ CATIONS GIVES 3.7 SIGMA

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L = MILLIEQUIVELENTS PER LITER, FT = FEET, MT = METERS. (M) = MEASURED, (E) = ESTIMATED, (R) = REPORTED. TR = TOTAL RECOVERABLE. TOT = TOTAL.

OW WA SO WI OW PW AT OTHER

OTHER AVAILABLE DATA
OTHER FILE NUMBERS:

PROJECT: — COST:
LAST EDIT DATE: 19-DEC 82 — BY: JD *JNS
PROCESSING PROGRAM: F1730P V2 (11/3/81) — PRINTED: 27 MAY 83

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
50.1	32.4	9.4	1.1	2.0	98.0	0.0	0.0

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: 0101514

MONTANA BUREAU OF MINES AND GEOLOGY
BUTTE,MONTANA 59701 (406)496-4101

WATER QUALITY ANALYSIS
LAB NO. B101514

STATE	MONTANA	COUNTY	CASCADE
LATITUDE-LONGITUDE	47D23'20"N 111D08'24"W	SITE LOCATION	19N 5E 19 AACD
UTM COORDINATES	Z N E	MBMG SITE	CF-12
TOPOGRAPHIC MAP	SOUTHEAST GREAT FALLS 7 1	STATION ID	472320111002401
GEOLOGIC SOURCE	* * *	SAMPLE SOURCE	STREAM
DRAINAGE BASIN	BB	LAND SURFACE ALTITUDE	3464. FT < 1(
AGENCY & SAMPLER	MBMG*JLS	WATER FLOW RATE	360.0 GPM
BOTTLE NUMBER	CF-12	FLOW MEAS METHOD	ESTIMATED
DATE SAMPLED	27-AUG-81	STAFF GAGE	
TIME SAMPLED	12:00 HOURS	STREAM STAGE	
LAB & ANALYST	MBMG*FNA	DEPTH TO SAMPLE	
DATE ANALYZED		TOTAL DEPTH OF WATER	
SAMPLE HANDLING	4220	STREAM WIDTH	
METHOD SAMPLED	GRAB		

WATER USE UNUSED

SAMPLING SITE COTTONWOOD CREEK * AT CENTERVILLE SCHOOL
DRAINAGE BASIN MISSOURI RIVER BETWEEN MARIAS RIVER AND LITTLE PRICKLY P

		MG/L	MEQ/L			MG/L	MEQ/L
CALCIUM	(CA)	151.	7.53	BICARBONATE	(HCO3)	.0	
MAGNESIUM	(MG)	60.1	4.94	CARBONATE	(CO3)	.0	
SODIUM	(NA)	15.8	0.69	CHLORIDE	(CL)	6.7	0.19
POTASSIUM	(K)	5.1	0.13	SULFATE	(SO4)	891.	18.55
IRON	(FE)	9.60	0.52	NITRATE	(AS N)	0.04	0.15
MANGANESE	(MN)	.93	0.03	FLUORIDE	(F)	1.44	0.08
SILICA	(SIO2)	17.8		PHOSPHATE TOT	(AS P)		
TOTAL CATIONS			13.85	TOTAL ANIONS			18.96

STANDARD DEVIATION OF ANION-CATION BALANCE (SIGMA)

LABORATORY PH	3.50	TOTAL HARDNESS AS CACO3	624.42
FIELD WATER TEMPERATURE	19.2 C	TOTAL ALKALINITY AS CACO3	
CALCULATED DISSOLVED SOLIDS		SODIUM ADSORPTION RATIO	0.28
SUM OF DISS. CONSTITUENT		RYZNAR STABILITY INDEX	
LAB SPEC.COND.(MICROMHOS/CM)	1598.	LANGLIER SATURATION INDEX	

PARAMETER	VALUE	PARAMETER	VALUE
TEMPERATURE, AIR (C)	22.	CNDUCTVY,FIELD MICROMHOS	1233.
FIELD PH	3.34	ALUMINUM, DISS (MG/L-AL)	43.3
NICKEL,DISS (MG/L AS NI)	.22	SILVER,DISS (MG/L AS AG)	.002
LEAD,DISS (MG/L AS PB)	<.04	BORON ,DISS (MG/L AS B)	.04
STRONTIUM,DISS (MG/L-SR)	.42	CADMIUM,DISS(MG/L AS CD)	.015
TITANIUM DIS(MG/L AS TI)	.022	CHROMIUM, DISS (MG/L-CR)	.014
VANADIUM,DISS(MG/L AS V)	.009	COPPER,DISS (MG/L AS CU)	.090
ZINC,DISS (MG/L AS ZN)	9.04	LITHIUM,DISS(MG/L AS LI)	.087
ZIRCONIUM DIS(MG/L AS ZR	.003	MOLYBDENUM,DISS(MG/L-MO)	.02
SELENIUM, DISS (UG/L-SE)	.8	ACIDITY,TOT(MG/L-CACO3)	342.

REMARKS: FLOW BY SUBTRACTION FROM CF-03 WEIR (DF-01=CA.15 GPM) *
MORE COMPACT FLOC-USED 2 FILTERS
LAB: AT 6.90 MG/L GIVES 20.1 MEQ CATIONS GIVES -2.9 SIGMA

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L
MILLIEQUIVALENTS PER LITER, FT = FEET, MT = METERS, (M) = MEASURED, (F) =
ESTIMATED, (R) = REPORTED, TR = TOTAL RECOVERABLE, TOT = TOTAL.

	GW	WA	SD	WI	OW	PW	AT	OTHER
OTHER AVAILABLE DATA								
OTHER FILE NUMBERS:								

PROJECT:		COST:	
LAST EDIT DATE:	19 FEB-82	BY:	TP *JKS
PROCESSING PROGRAM:	F1730P V2 (11/3/81)	PRINTED:	27 MAY-83

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
54.7	37.2	5.2	1.0	1.0	99.0	0.0	0.0

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: B101514

MONTANA BUREAU OF MINES AND GEOLOGY — WATER QUALITY ANALYSIS
BUTTE, MONTANA 59701 (406)496 4101 — LAB NO. 8101515

STATE	MONTANA	COUNTY	CASCADE
LATITUDE-LONGITUDE	47D19'23"N 111D09'05"W	SITE LOCATION	18N 5E 7*CCAA (
UTM COORDINATES	Z N E	MBMG SITE OF	16
TOPOGRAPHIC MAP	STOCKETT 7 1/2'	STATION ID	471923111090501
GEOLOGIC SOURCE	* *	SAMPLE SOURCE	STREAM
DRAINAGE BASIN	BB	LAND SURFACE ALTITUDE	3855. FT 10
AGENCY & SAMPLER	MBMG*JLS	WATER FLOW RATE	350.0 GPM
BOTTLE NUMBER	OF 16	FLOW MEAS METHOD	WEIR
DATE SAMPLED	28-AUG 81		STAFF GAGE
TIME SAMPLED	18:00 HOURS		STREAM STAGE
LAB & ANALYST	MBMG*ENA		DEPTH TO SAMPLE
DATE ANALYZED	29-SEP 81	TOTAL DEPTH OF WATER	0.6 FT (M)
SAMPLE HANDLING	4220		STREAM WIDTH
METHOD SAMPLED	GRAB		

WATER USE UNUSED

SAMPLING SITE COTTONWOOD CREEK * BELOW BILL SHIRLEY FARM
DRAINAGE BASIN MISSOURI RIVER BETWEEN MARIAS RIVER AND LITTLE PRICKLY PE

	MG/L	MEQ/L		MG/L	MEQ/L
CALCIUM (CA)	56.7	2.83	BICARBONATE (HCO3)	285.	4.67
MAGNESIUM (MG)	34.1	2.81	CARBONATE (CO3)	0.	
SODIUM (NA)	11.4	0.50	CHLORIDE (CL)	3.7	0.10
POTASSIUM (K)	3.1	0.08	SULFATE (SO4)	49.1	1.02
IRON (FE)	.30	0.02	NITRATE (AS N)	5.33	0.38
MANGANESE (MN)	.032	0.00	FLUORIDE (F)	.57	0.03
SILICA (SIO2)	8.4		PHOSPHATE TOT (AS P)		
TOTAL CATIONS		6.23	TOTAL ANIONS		6.21

STANDARD DEVIATION OF ANION-CATION BALANCE (SIGMA) 0.10

LABORATORY PH	8.26	TOTAL HARDNESS AS CACO3	281.94
FIELD WATER TEMPERATURE	21.4 C	TOTAL ALKALINITY AS CACO3	233.75
CALCULATED DISSOLVED SOLIDS	313.13	SODIUM ADSORPTION RATIO	0.30
SUM OF DISS. CONSTITUENT	452.73	RYZNAR STABILITY INDEX	6.50
LAB SPEC.COND.(MICROMHOS/CM)	417.6	LANGLIER SATURATION INDEX	0.80

PARAMETER	VALUE	PARAMETER	VALUE
TEMPERATURE, AIR (C)	20. C	CNDUCTVY,FIELD MICROMHOS	970.
ALUMINUM, DISS (MG/L-AL)	.31	NICKEL,DISS (MG/L AS NI)	.02
SILVER,DISS (MG/L AS AG)	<.002	LEAD,DISS (MG/L AS PB)	<.04
BORON ,DISS (MG/L AS B)	<.02	STRONTIUM,DISS (MG/L SR)	.27
CADMIUM,DISS(MG/L AS CD)	<.002	TITANIUM DIS(MG/L AS TI)	.003
CHROMIUM, DISS (MG/L-CR)	<.002	VANADIUM,DISS(MG/L AS V)	<.001
COPPER,DISS (MG/L AS CU)	<.002	ZINC,DISS (MG/L AS ZN)	.013
LITHIUM,DISS(MG/L AS LI)	.008	ZIRCONIUM DIS(MG/L AS ZR	<.003
MOLYBDENUM,DISS(MG/L-MO)	.04	SELENIUM, DISS (UG/L-SE)	.6
SELENIUM,TR (UG/L AS SE)	.6		

REMARKS: WATER IS MURKY, SOME FE-HYDROXIDE PRECIPITATES*MUDDY COLOR*REQUIRED
FILTERS*BELOW CONF OF STREAM THRU SHIRLEY RANCH AND ACID STREAM DRAI
ING RESERVOIR*PH HIGHLY UNSTABLE * ELECTRODE POISONS*CROSS REF 81018

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L
MILLIEQUIVELENTS PER LITER. FT = FEET, MI = MILES. (M) = MEASURED, (E) =
ESTIMATED, (R) = REPORTED. TR = TOTAL RECOVERABLE. TOT = TOTAL.

QW WA SO WI OW PW AT OTHER

OTHER AVAILABLE DATA
OTHER FILE NUMBERS:

PROJECT:		COST:	
LAST EDIT DATE:	25-NOV-81	BY:	TP *TP
PROCESSING PROGRAM:	F1730P V2 (11/3/81)	PRINTED:	27 MAY-83

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
45.5	45.2	8.0	1.3	1.8	17.6	80.6	0.0

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: 8101515

MONTANA BUREAU OF MINES AND GEOLOGY
BUTTE,MONTANA 59701 (406)496-4101

WATER QUALITY ANALYSIS
LAB NO. 81Q1517

STATE	MONTANA	COUNTY	CASCADE
LATITUDE-LONGITUDE	47D23'21"N 111D08'21"W	SITE LOCATION	19N 5E 19*AACD
UTM COORDINATES	Z N E	MBMG SITE	DF-01
TOPOGRAPHIC MAP	SOUTHEAST GREAT FALLS 7 1	STATION ID	472321111082101
GEOLOGIC SOURCE	* * *	SAMPLE SOURCE	STREAM
DRAINAGE BASIN	BB	LAND SURFACE ALTITUDE	3464. FT
AGENCY + SAMPLER	MBMG*JLS	WATER FLOW RATE	15. GPM
BOTTLE NUMBER	DF-01	FLOW MEAS METHOD	ESTIMATED
DATE SAMPLED	27-AUG-81	STAFF GAGE	
TIME SAMPLED	10:30 HOURS	STREAM STAGE	
LAB + ANALYST	MBMG*ENA	DEPTH TO SAMPLE	
DATE ANALYZED	12-OCT-81	TOTAL DEPTH OF WATER	
SAMPLE HANDLING	4220	STREAM WIDTH	
METHOD SAMPLED	GRAB		

WATER USE UNUSED

SAMPLING SITE SAND COULEE CR*UPSTREAM FROM COTTONWOOD CR
DRAINAGE BASIN MISSOURI RIVER BETWEEN MARIAS RIVER AND LITTLE PRICKLY PI

	MG/L	MEQ/L		MG/L	MEQ/L
CALCIUM (CA)	33.2	1.66	BICARBONATE (HCO3)	155.2	2.54
MAGNESIUM (MG)	30.	2.47	CARBONATE (CO3)	0.	
SODIUM (NA)	8.	0.35	CHLORIDE (CL)	2.8	0.08
POTASSIUM (K)	3.4	0.09	SULFATE (SO4)	94.	1.96
IRON (FE)	.076	0.00	NITRATE (AS N)	.05	0.00
MANGANESE (MN)	.022	0.00	FLUORIDE (F)	.51	0.03
SILICA (SIO2)	4.0		PHOSPHATE TOT (AS P)		
TOTAL CATIONS		4.56	TOTAL ANIONS		4.61

STANDARD DEVIATION OF ANION-CATION BALANCE (SIGMA) 0.26

LABORATORY PH	7.96	TOTAL HARDNESS AS CACO3	206.38
FIELD WATER TEMPERATURE	25.0 C	TOTAL ALKALINITY AS CACO3	127.29
CALCULATED DISSOLVED SOLIDS	252.51	SODIUM ADSORPTION RATIO	0.24
SUM OF DISS. CONSTITUENT	331.26	RYZNAR STABILITY INDEX	7.79
LAB SPEC.COND.(MICROMHOS/CM)	412.0	LANGLIER SATURATION INDEX	0.09

PARAMETER	VALUE	PARAMETER	VALUE
TEMPERATURE, AIR (C)	22.0 C	CNDUCTVY,FIELD MICROMHOS	370.
FIELD PH	8.41	ALUMINUM, DISS (MG/L-AL)	.28
NICKEL,DISS (MG/L AS NI)	.02	SILVER,DISS (MG/L AS AG)	<.002
LEAD,DISS (MG/L AS PB)	<.04	BORON ,DISS (MG/L AS B)	<.02
STRONTIUM,DISS (MG/L-SR)	.55	CADMIUM,DISS(MG/L AS CD)	<.002
TITANIUM DIS(MG/L AS TI)	<.001	CHROMIUM, DISS (MG/L-CR)	<.002
VANADIUM,DISS(MG/L AS V)	<.001	COPPER,DISS (MG/L AS CU)	.002
ZINC,DISS (MG/L AS ZN)	.006	LITHIUM,DISS(MG/L AS LI)	.007
ZIRCONIUM DIS(MG/L AS ZR	.003	MOLYBDENUM,DISS(MG/L-MO)	<.02
SELENIUM, DISS (UG/L-SE)	.4	SELENIUM,TR (UG/L AS SE)	.3

REMARKS: USED 6 FILTERS - 80-100 ML/FILTER * GEL-LIKE PPT. ON FILTER (SOAP?) *
CROSS REF. 81Q1839 *

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L = MILLIEQUIVELENTS PER LITER. FT = FEET, MT = METERS. (M) = MEASURED, (E) = ESTIMATED, (R) = REPORTED. TR = TOTAL RECOVERABLE. TOT = TOTAL.

QW WA SS WI OW PW AT OTHER

OTHER AVAILABLE DATA
OTHER FILE NUMBERS:

PROJECT:		COST:	
LAST EDIT DATE:	25-NOV-81	BY:	TP *TP
PROCESSING PROGRAM:	F1730P V2 (11/3/81)	PRINTED:	27-MAY-83

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
36.3	54.1	7.6	1.9	1.7	42.7	55.5	0.0

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: 81Q1517

Ready

D-7

DAILY DISCHARGE DATA AND STREAMFLOW HYDROGRAPHS

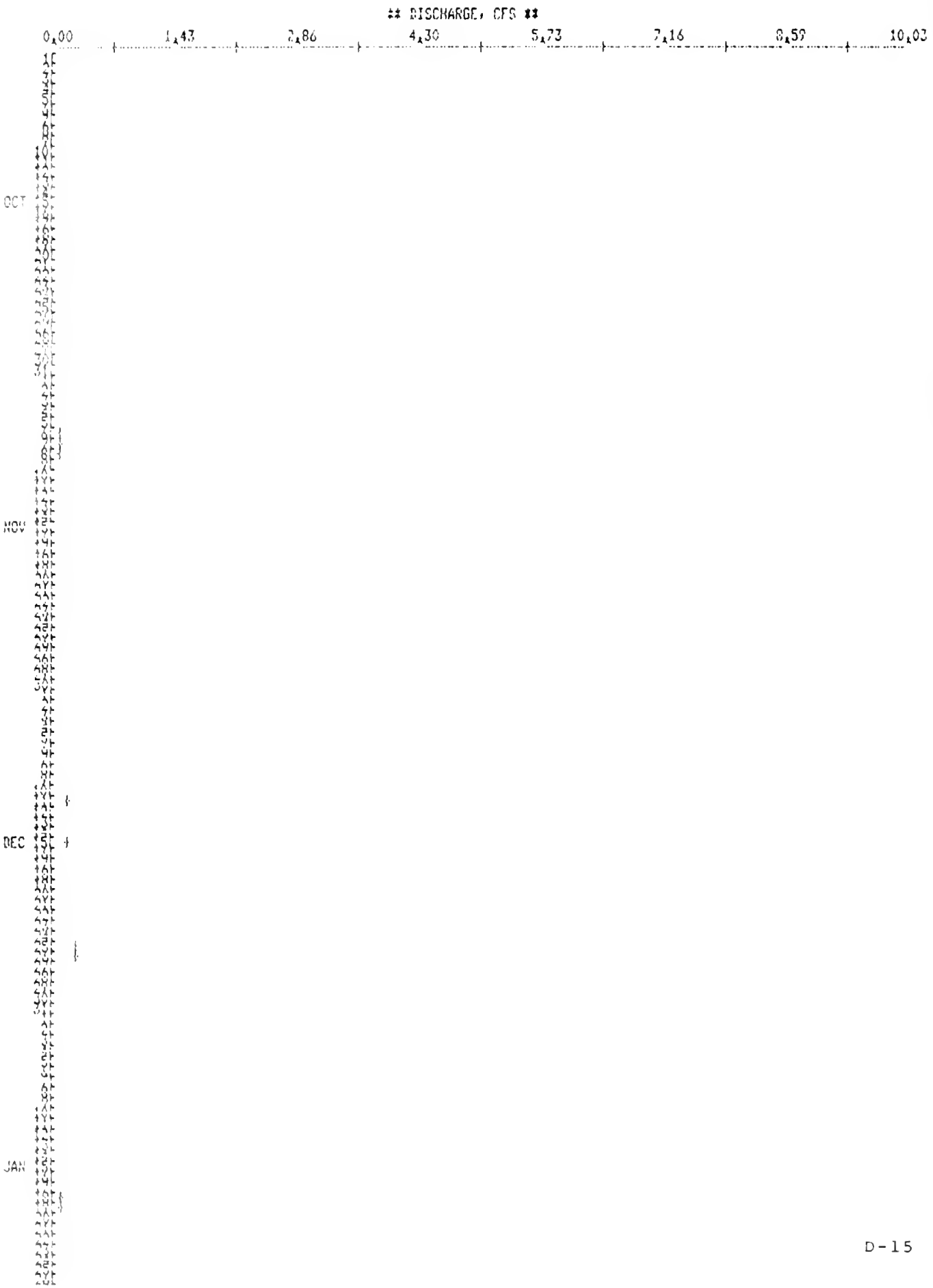
Stations:

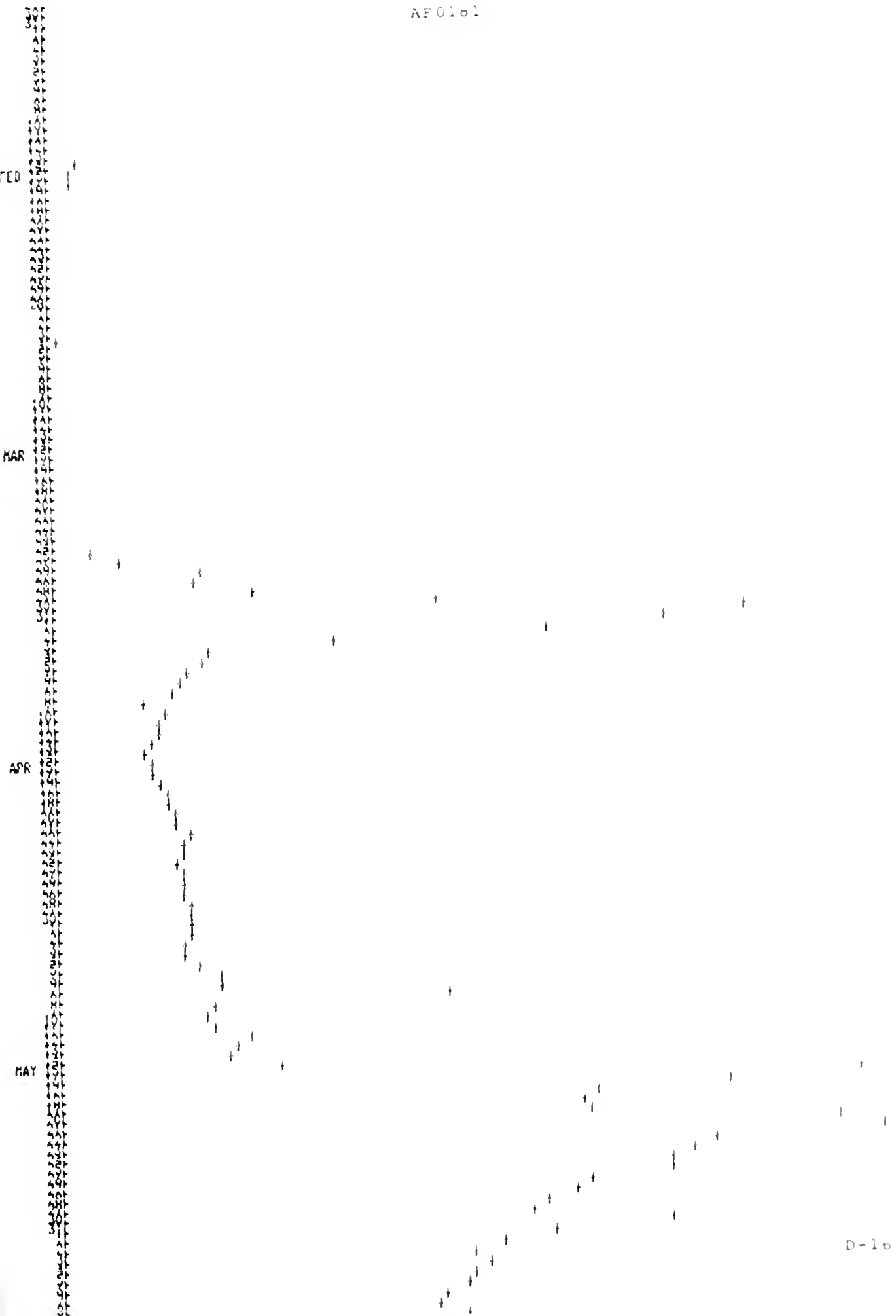
AF01
CF02
CF03

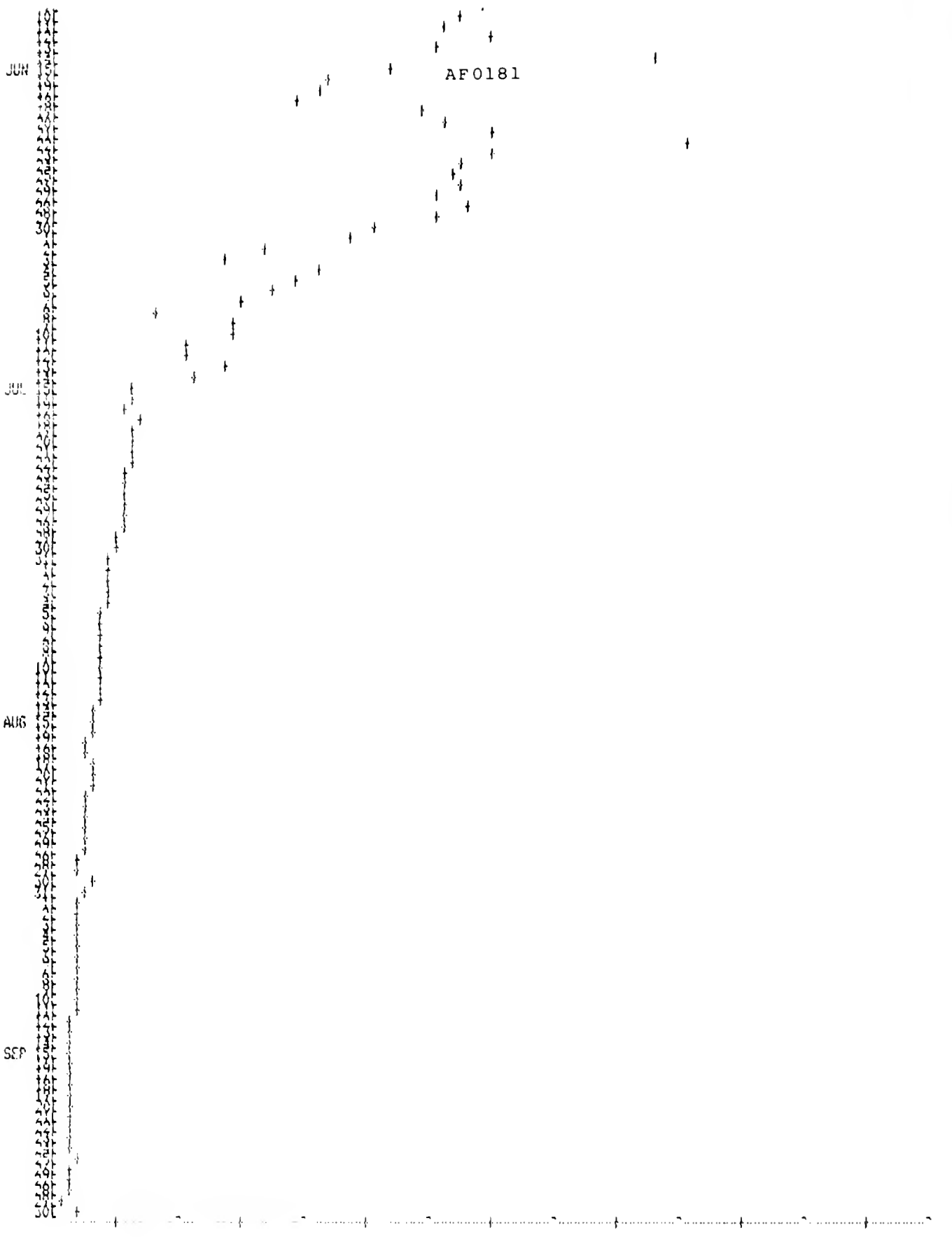
' STATION AF0181 STRAIGHT CREEK NEAR SAND COULEE, MT.
WATER YEAR FROM SEPT 1980 TO OCT 1 1981 T 19N R 04E SEC 12 DCBC LAT 0 0 0 N LONG 0 0 0 W

MEAN DISCHARGE, CFS

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	**********	**********	0.000	0.000	0.000	0.000	7.504	1.685	6.067	3.433	0.701	0.347
2	**********	**********	0.000	0.002	0.000	0.000	6.003	1.668	5.391	2.442	0.673	0.293
3	**********	**********	0.000	0.004	0.000	0.000	3.455	1.523	5.041	2.015	0.651	0.293
4	**********	**********	0.000	0.003	0.000	0.137	1.890	1.523	5.214	3.100	0.663	0.325
5	**********	**********	0.000	0.004	0.000	0.031	1.801	1.720	5.020	2.048	0.618	0.325
6	**********	0.099	0.000	0.017	0.000	0.000	1.660	1.989	4.935	2.574	0.610	0.312
7	**********	0.109	0.000	0.015	0.000	0.000	1.562	2.010	4.688	2.175	0.606	0.293
8	**********	0.101	0.000	0.017	0.000	0.000	1.500	4.805	4.607	1.252	0.618	0.274
9	**********	0.071	0.000	0.043	0.000	0.000	1.122	1.969	4.935	2.104	0.610	0.283
10	**********	0.064	0.055	0.006	0.000	0.000	1.417	1.791	4.688	2.067	0.583	0.283
11	**********	0.049	0.190	0.008	0.000	0.000	1.326	1.905	4.527	1.577	0.575	0.274
12	**********	0.028	0.051	0.011	0.000	0.000	1.276	2.400	5.031	1.577	0.568	0.264
13	**********	0.004	0.029	0.009	0.018	0.000	1.184	2.236	4.449	1.994	0.549	0.264
14	**********	0.000	0.080	0.008	0.378	0.000	1.163	2.067	6.958	1.660	0.534	0.254
15	**********	0.000	0.214	0.005	0.344	0.000	1.206	2.772	3.899	0.955	0.520	0.254
16	**********	0.001	0.034	0.000	0.270	0.000	1.229	7.760	3.198	0.949	0.448	0.254
17	**********	0.010	0.000	0.002	0.069	0.000	1.326	8.235	3.078	0.883	0.427	0.245
18	**********	0.009	0.000	0.121	0.012	0.000	1.352	6.579	2.793	1.009	0.444	0.236
19	**********	0.007	0.000	0.136	0.000	0.000	1.406	6.414	4.294	0.962	0.448	0.236
20	**********	0.004	0.000	0.064	0.000	0.000	1.434	6.515	4.527	0.911	0.461	0.227
21	**********	0.037	0.000	0.027	0.000	0.000	1.500	9.559	5.064	0.899	0.458	0.236
22	**********	0.000	0.000	0.007	0.000	0.000	1.685	10.026	7.337	0.896	0.409	0.227
23	**********	0.001	0.000	0.000	0.000	0.053	1.538	7.975	5.020	0.808	0.394	0.210
24	**********	0.033	0.000	0.000	0.000	0.053	1.554	7.701	4.738	0.680	0.400	0.210
25	**********	0.000	0.324	0.000	0.000	0.460	1.463	7.434	4.607	0.883	0.431	0.342
26	**********	0.011	0.318	0.000	0.000	0.893	1.585	7.518	4.708	0.880	0.431	0.231
27	**********	0.050	0.086	0.000	0.000	1.835	1.554	6.489	4.419	0.835	0.389	0.199
28	**********	0.049	0.002	0.000	0.000	1.764	1.523	6.338	4.769	0.813	0.336	0.195
29	**********	0.024	0.003	0.000	0.000	2.495	1.685	5.923	4.449	0.795	0.336	0.151
30	**********	0.003	0.000	0.000	0.000	4.713	1.651	5.734	3.699	0.749	0.451	0.314
31	**********	0.000	0.000	0.000	0.000	8.450	0.000	7.490	0.000	0.699	0.436	0.000
TOTAL	*********	**********	1.385	0.507	1.090	20.892	56.553	151.753	142.171	45.706	15.781	7.854
MEAN	*********	*********	0.045	0.016	0.039	0.674	1.885	4.895	4.739	1.474	0.509	0.262
MAX	0.000	0.109	0.324	0.136	0.378	8.450	7.504	10.026	7.337	3.433	0.701	0.347
MIN	*********	0.000	0.000	0.000	0.000	0.000	1.122	1.523	2.793	0.699	0.336	0.151
AC-FT	*********	**********	2.747	1.006	2.163	41.439	112.172	300.997	281.993	90.657	31.302	15.578


** DISCHARGE, CFS **
0.00
1.43
2.86
4.30
5.73
7.16
8.59
10.03
OCT
NOV
DEC
JAN


FEB
MAR
APR
MAY


AF0181
JUN
JUL
AUG
SEP
** DISCHARGE, CFS **
0.00
1.43
2.86
4.30
5.73
7.16
8.59
10.03

STOP
Ready

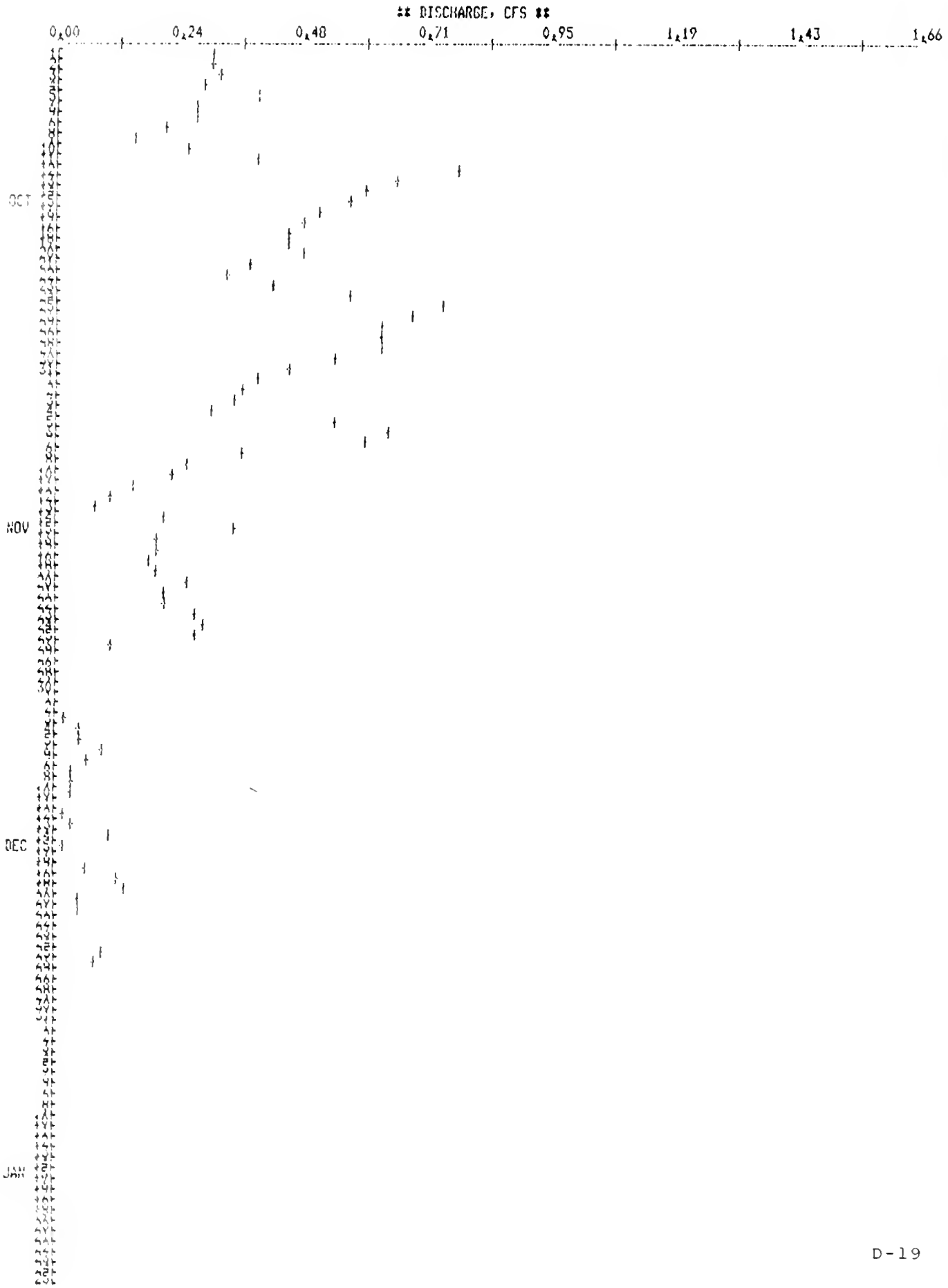
STATION AF0182 STRAIGHT CREEK NEAR SAND COULEE, MT.
WATER YEAR FROM SEPT 1981 TO OCT 1 1982 T 19N R 04E SEC 12 DCDC LAT 0 0 0 N LONG 0 0 0 W

MEAN DISCHARGE, CFS [1]

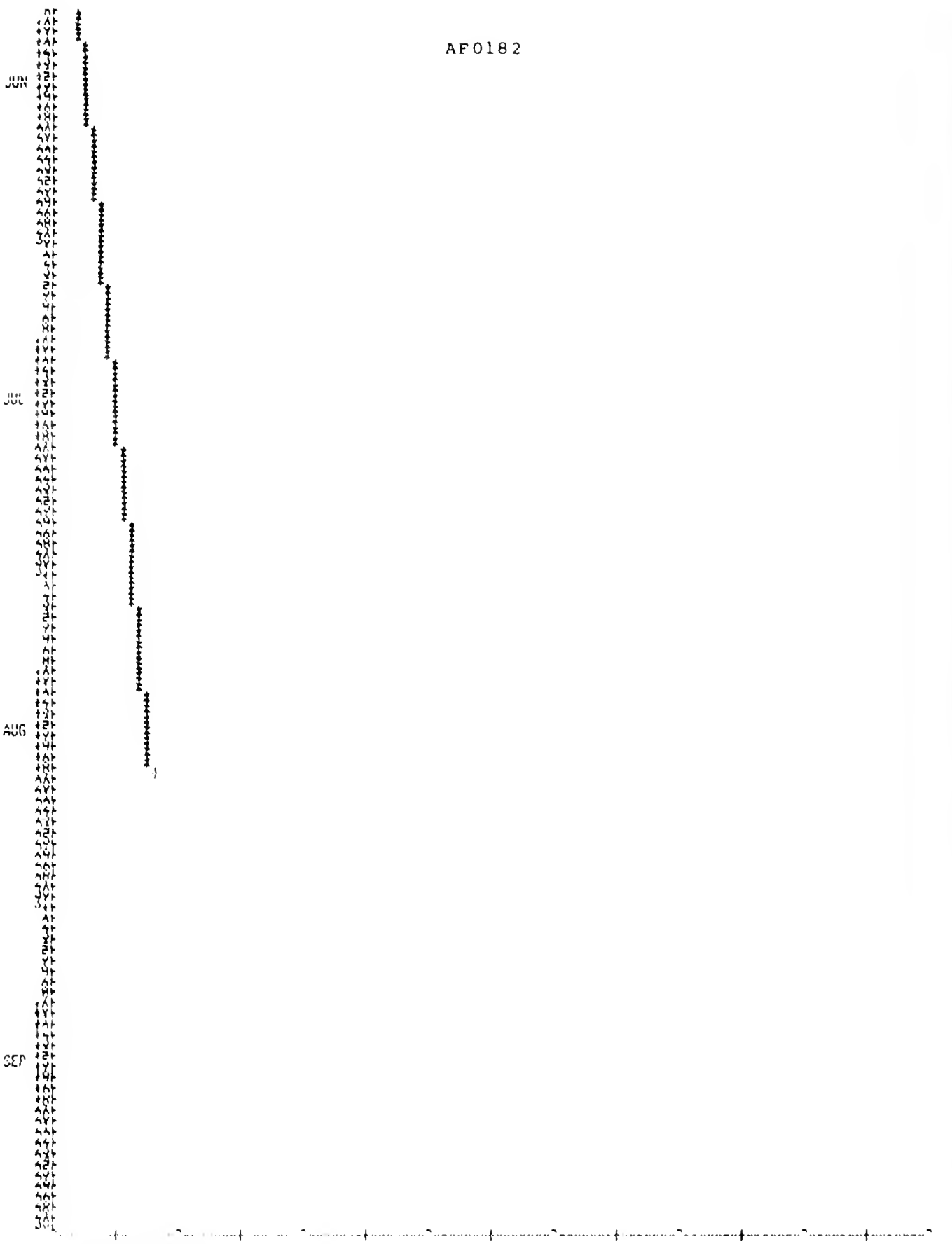
DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	0.304	0.394	0.000	0.000	0.000	0.000	0.325	0.062*	0.038*	0.097*	0.156*	**********
2	0.304	0.359	0.000	0.000	0.000	0.000	0.119	0.073*	0.040*	0.099*	0.160*	**********
3	0.314	0.347	0.026	0.000	0.000	0.000	0.048	0.083*	0.042*	0.101*	0.162*	**********
4	0.293	0.306	0.047	0.000	0.000	0.000	0.110	0.094	0.044*	0.103*	0.164*	**********
5	0.389	0.549	0.058	0.000	0.000	0.000	0.148	0.017	0.046*	0.105*	0.166*	**********
6	0.274	0.641	0.095	0.000	0.000	0.000	0.263	0.162	0.048*	0.107*	0.168*	**********
7	0.269	0.597	0.072	0.000	0.000	0.000	0.003	0.105	0.050*	0.109*	0.170*	**********
8	0.210	0.358	0.032	0.000	0.000	0.000	0.166	0.070	0.052*	0.111*	0.172*	**********
9	0.155	0.254	0.033	0.000	0.000	0.000	0.316	0.130	0.054*	0.113*	0.174*	**********
10	0.259	0.228	0.031	0.000	0.000	0.008	0.736	0.109	0.056*	0.115*	0.176*	**********
11	0.391	0.162	0.014	0.000	0.000	0.092	1.664	0.016	0.058*	0.117*	0.178*	**********
12	0.781	0.116	0.017	0.000	0.000	0.106	0.795	0.004	0.060*	0.119*	0.180*	**********
13	0.667	0.087	0.030	0.000	0.000	0.127	0.809	0.001	0.062*	0.121*	0.182*	**********
14	0.602	0.210	0.108	0.000	0.000	0.104	0.587	0.003*	0.064*	0.123*	0.184*	**********
15	0.572	0.344	0.024	0.000	0.000	0.038	0.476	0.005*	0.066*	0.125*	0.186*	**********
16	0.513	0.194	0.010	0.000	0.000	0.008	0.657	0.007*	0.068*	0.127*	0.188*	**********
17	0.485	0.202	0.073	0.000	0.000	0.009	0.328	0.009*	0.070*	0.129*	0.190*	**********
18	0.458	0.186	0.124	0.000	0.000	0.003	0.277	0.011*	0.072*	0.131*	0.192*	**********
19	0.456	0.202	0.137	0.000	0.000	0.000	0.321	0.013*	0.074*	0.133*	0.194	**********
20	0.490	0.253	0.056	0.000	0.000	0.099	0.431	0.015*	0.076*	0.135*	**********	**********
21	0.373	0.214	0.054	0.000	0.000	0.054	0.261	0.017*	0.078*	0.137*	**********	**********
22	0.330	0.219	0.010	0.000	0.000	0.260	0.069	0.019*	0.080*	0.139*	**********	**********
23	0.419	0.269	0.013	0.000	0.000	0.290	0.033	0.020*	0.082*	0.141*	**********	**********
24	0.573	0.283	0.001	0.000	0.000	0.136	0.034*	0.022*	0.084*	0.143*	**********	**********
25	0.756	0.282	0.091	0.000	0.000	0.086	0.035*	0.024*	0.086*	0.145*	**********	**********
26	0.684	0.119	0.079	0.000	0.000	0.150	0.036*	0.026*	0.087*	0.147*	**********	**********
27	0.634	0.010	0.000	0.000	0.000	0.326	0.038*	0.028*	0.089*	0.149*	**********	**********
28	0.634	0.000	0.000	0.000	0.000	0.723	0.039*	0.030*	0.091*	0.151*	**********	**********
29	0.634	0.000	0.000	0.000	0.000	0.732	0.040	0.032*	0.093*	0.153*	**********	**********
30	0.542	0.000	0.000	0.000	0.000	0.354	0.051*	0.034*	0.095*	0.154*	**********	**********
31	0.458	0.000	0.000	0.000	0.000	0.293	0.000	0.036*	0.000	0.156*	**********	0.000
TOTAL	14.223	7.386	1.235	0.000	0.000	3.999	9.213	1.271	2.004	3.934	**********	********
MEAN	0.459	0.246	0.040	0.000	0.000	0.129	0.307	0.041	0.067	0.127	********	********
MAX	0.781	0.641	0.137	0.000	0.000	0.732	1.664	0.162	0.095	0.156	0.194	0.000
MIN	0.155	0.000	0.000	0.000	0.000	0.000	0.003	0.001	0.038	0.097	0.158	********
AC-FT	28.211	14.650	2.450	0.000	0.000	7.932	18.274	2.521	3.975	7.803	**********	********

1) Record accuracy affected by siltation and corrosion of weir plate, worsening throughout year.

* Interpolated value.


** DISCHARGE, CFS **
0.00
0.24
0.48
0.71
0.95
1.19
1.43
1.66
OCT
NOV
DEC
JAN

MAR
APR
MAY

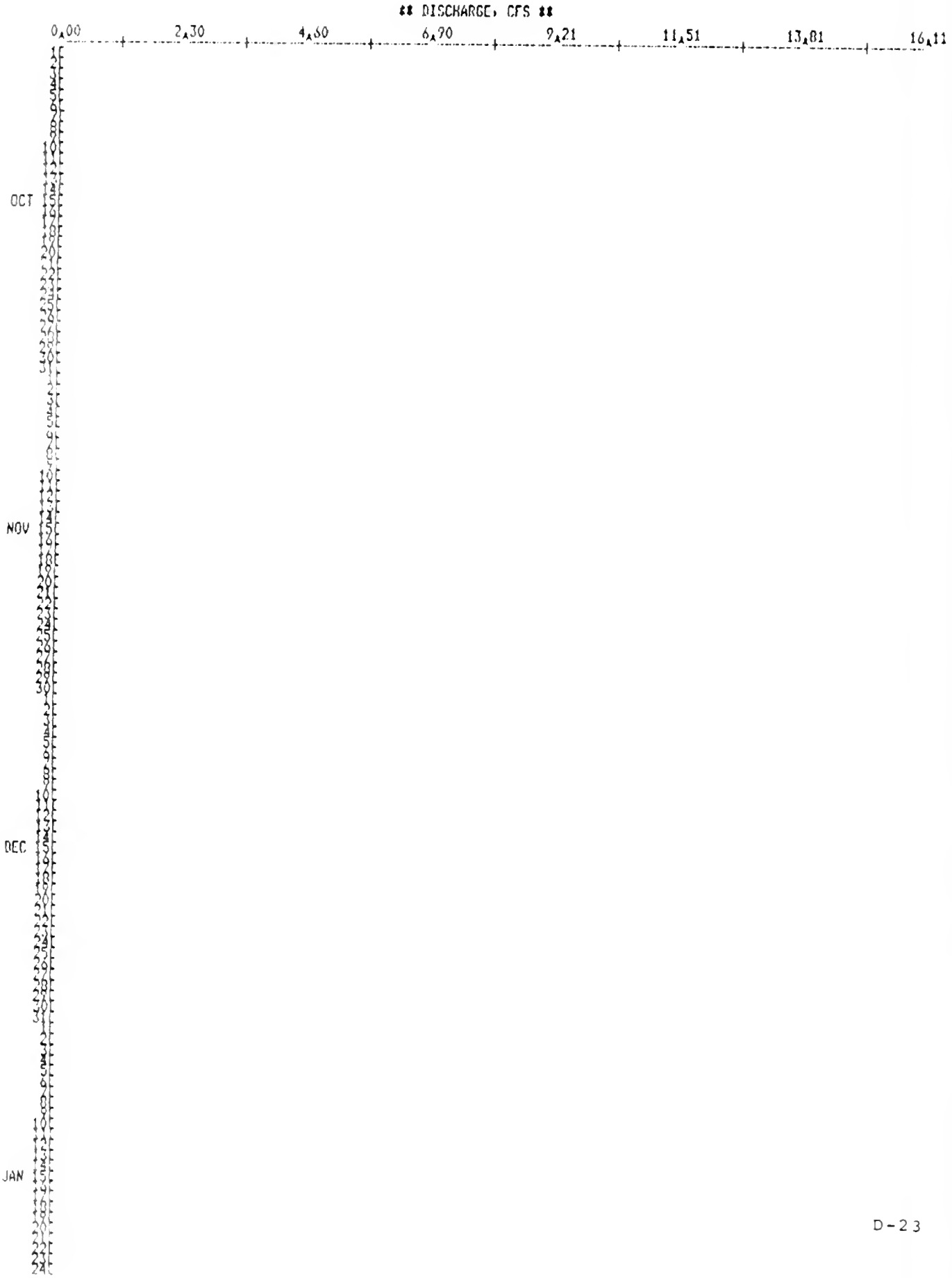

JUN
JUL
AUG
SEP
** DISCHARGE, CFS **
0.00
0.24
0.48
0.71
0.95
1.19
1.43
1.66
STOP
Ready

' STATION CF0281 SAND COULEE CREEK NEAR TRACY, MT.
WATER YEAR FROM SEPT 1980 TO OCT 1 1981 T 19N R 05E SEC 19 AACA LAT 0 0 0 N LONG 0 0 0 W

MEAN DISCHARGE, CFS

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	**********	**********	0.000	0.000	0.000	0.000	14.818	1.857	1.698*	1.544*	1.385*	1.195
2	**********	**********	0.000	0.000	0.000	0.000	14.176	1.852* 2	1.693*	1.539*	1.380*	0.959
3	**********	**********	0.000	0.000	0.000	0.000	13.186	1.846*	1.687*	1.534*	1.375*	0.929
4	**********	**********	0.000	0.000	0.000	0.000	11.286	1.841*	1.682*	1.528*	1.369*	0.929
5	**********	**********	0.000	0.000	0.000	0.000	11.014	1.836*	1.677*	1.523*	1.364*	0.942
6	**********	0.000	0.000	0.000	0.000	0.000	14.050	1.831*	1.672*	1.518*	1.359*	0.955
7	**********	0.000	0.000	0.000	0.000	0.000	10.037	1.826*	1.667*	1.513*	1.354*	0.942
8	**********	0.000	0.000	0.000	0.000	0.000	9.070	1.821*	1.662*	1.508*	1.349*	0.828
9	**********	0.000	0.000	0.000	0.000	0.000	7.773	1.816*	1.657*	1.503*	1.344*	0.714
10	**********	0.000	0.000	0.000	0.000	0.000	6.760	1.811*	1.652*	1.498*	1.339*	0.663
11	**********	0.000	0.000	0.000	0.000	0.000	6.669	1.805*	1.646*	1.492*	1.333*	0.651
12	**********	0.000	0.000	0.000	0.000	0.000	6.376	1.800*	1.641*	1.487*	1.328*	0.599
13	**********	0.000	0.000	0.000	0.000	0.000	5.572	1.795*	1.636*	1.482*	1.323*	0.572
14	**********	0.000	0.000	0.000	0.000	0.000	5.138	1.790*	1.631*	1.477*	1.318*	0.595
15	**********	0.000	0.000	0.000	0.000	0.000	5.009	1.785*	1.626*	1.472*	1.313*	0.579
16	**********	0.000	0.000	0.000	0.000	0.000	4.657	1.780*	1.621*	1.467*	1.308*	0.549
17	**********	0.000	0.000	0.000	0.000	0.000	4.410	1.775*	1.616*	1.462*	1.303*	0.499
18	**********	0.000	0.000	0.000	0.000	0.000	3.917	1.770*	1.610*	1.457*	1.298*	0.422
19	**********	0.000	0.000	0.000	0.000	0.000	3.623	1.764*	1.605*	1.451*	1.292*	0.391
20	**********	0.000	0.000	0.000	0.000	0.000	3.750	1.759*	1.600*	1.446*	1.287*	0.448
21	**********	0.000	0.000	0.000	0.000	0.000	4.607	1.754*	1.595*	1.441*	1.282	0.478
22	**********	0.000	0.000	0.000	0.000	0.000	3.361	1.749*	1.590*	1.436*	1.122	**********
23	**********	0.000	0.000	0.000	0.000	0.000	2.883	1.744*	1.585*	1.431*	1.031	**********
24	**********	0.000	0.000	0.000	0.000	0.000	2.658	1.739*	1.580*	1.426*	1.015	**********
25	**********	0.000	0.000	0.000	0.000	0.000	2.523	1.734*	1.575*	1.421*	0.984	**********
26	**********	0.000	0.000	0.000	0.000	0.000	2.672	1.728*	1.569*	1.416*	0.969	**********
27	**********	0.000	0.000	0.000	0.000	2.282	2.793	1.723*	1.564*	1.410*	0.969	**********
28	**********	0.000	0.000	0.000	0.000	1.879	2.424	1.718*	1.559*	1.405*	0.955	**********
29	**********	0.000	0.000	0.000	0.000	7.951	2.358	1.713*	1.554*	1.400*	0.926	**********
30	**********	0.000	0.000	0.000	0.000	16.109 1	2.056	1.708*	1.549*	1.395*	1.040	**********
31	**********	0.000	0.000	0.000	0.000	13.896	0.000	1.703*	0.000	1.390*	1.824	0.000
TOTAL	*********	**********	0.000	0.000	0.000	42.117	189.624	55.173	48.699	45.472	38.840	**********
MEAN	*********	*********	0.000	0.000	0.000	1.359	6.321	1.780	1.623	1.467	1.253	*********
MAX	0.000	0.000	0.000	0.000	0.000	16.109	14.818	1.857	1.698	1.544	1.824	1.195
MIN	*********	0.000	0.000	0.000	0.000	0.000	2.056	1.703	1.549	1.390	0.926	0.391
AC-FT	*********	**********	0.000	0.000	0.000	83.539	376.114	109.434	96.594	90.193	77.037	**********

1) Weir capacity exceeded
2) Weir washout, no record from 5-2 through 8-20
* Interpolated value

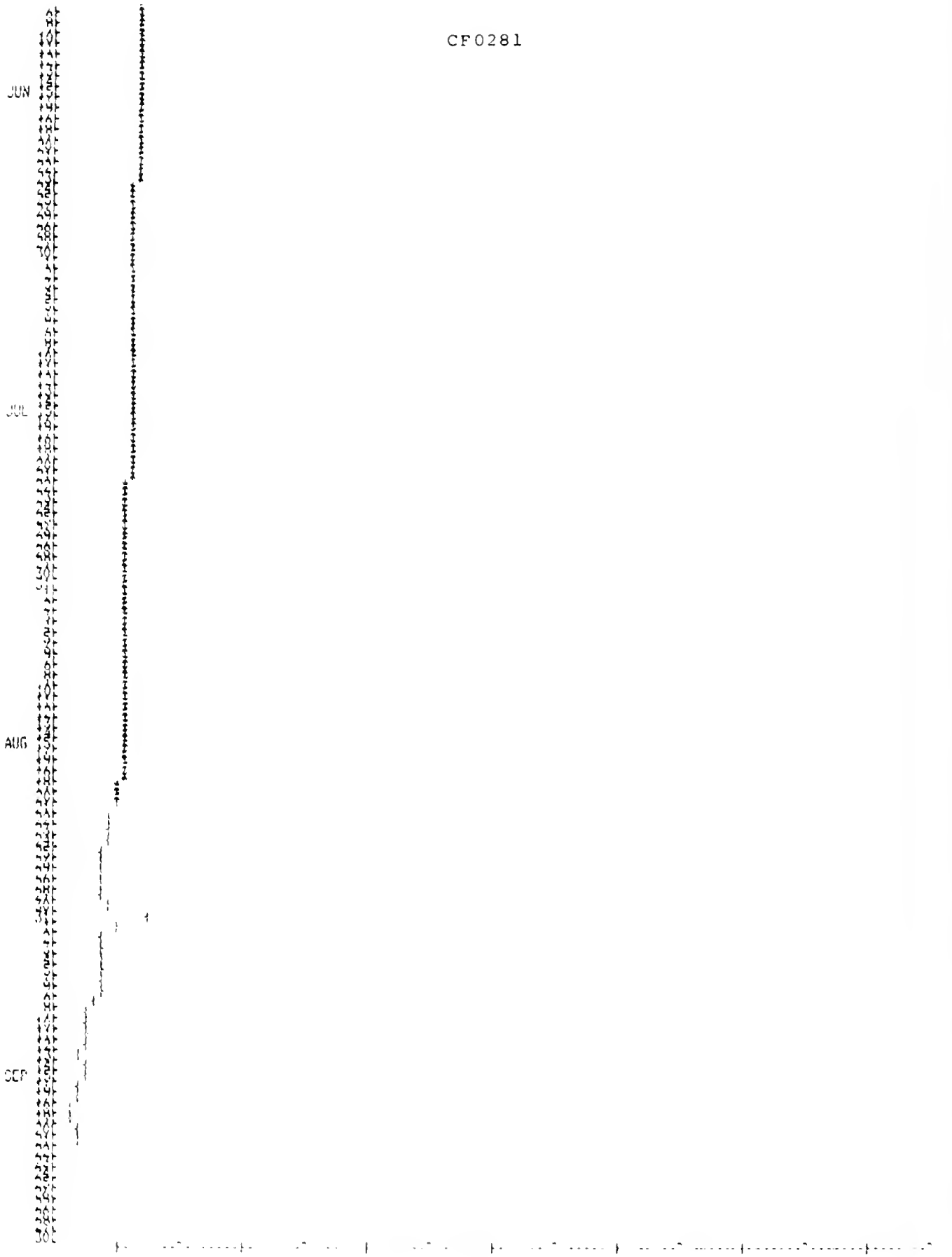

** DISCHARGE, CFS **
0.00
2.30
4.60
6.90
9.21
11.51
13.81
16.11
OCT
NOV
DEC
JAN

FEB

MAR

APR

MAY


JUN
JUL
AUG
SEP
** DISCHARGE, CFS **
0.00
2.30
4.60
6.90
9.21
11.51
13.81
16.11

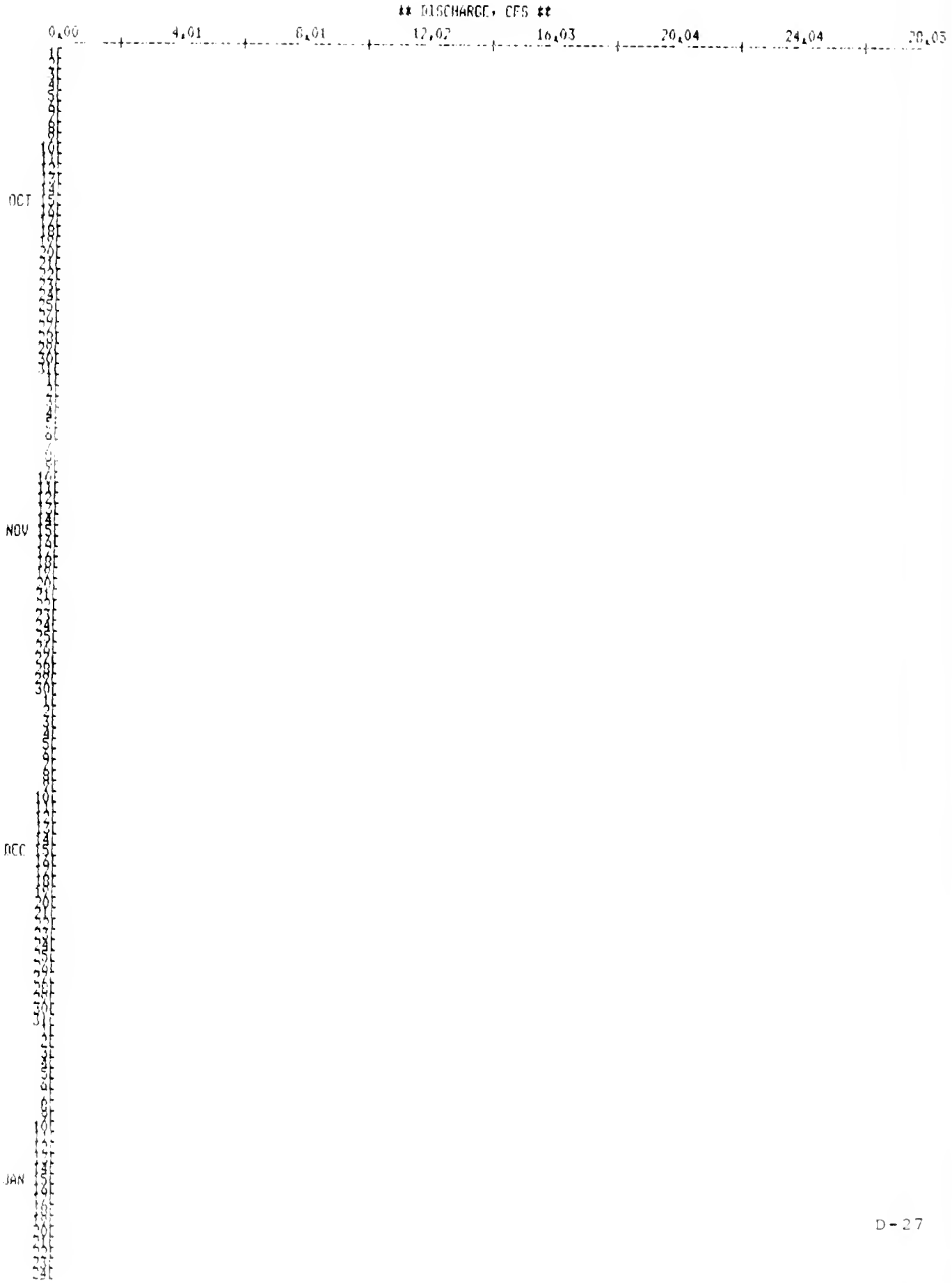
STOP
Ready

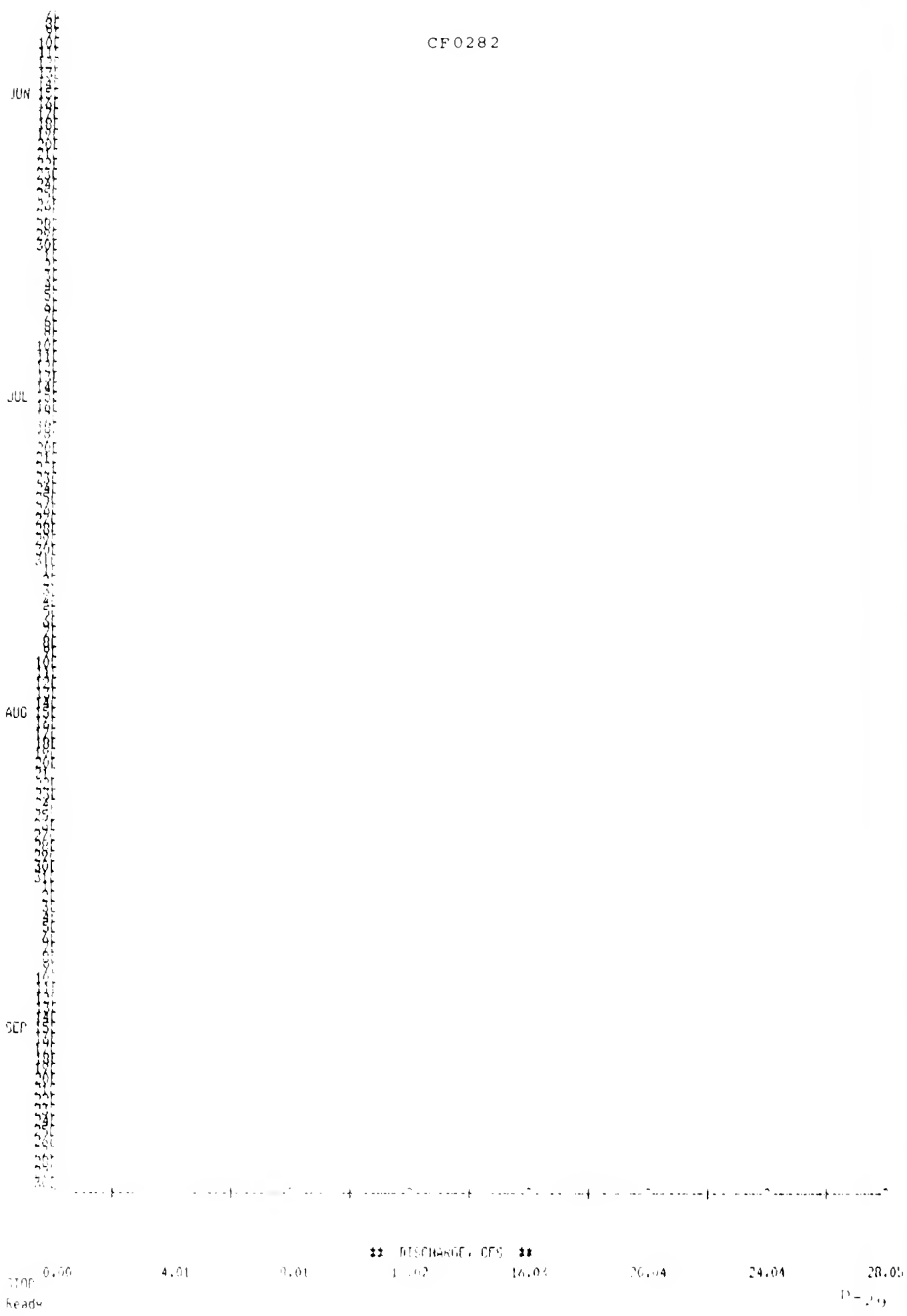
STATION 06292 SAND COULEE CREEK NEAR TRACY, MT.
WATER YEAR FROM SEPT 1981 TO OCT 1 1982 T 19N R 05E SEC 19 AACA LAT 0 0 0 N LONG 0 0 0 W

MEAN DISCHARGE, CFS

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SE
1	*********	*********	*********	0.025*	0.000*	0.000	0.000*	*********	*********	*********	*********	*********
2	*********	*********	*********	0.022*	0.000*	0.000	0.000*	*********	*********	*********	*********	*********
3	*********	*********	0.130	0.018*	0.000*	0.000	0.000*	*********	*********	*********	*********	*********
4	*********	*********	0.126*	0.014*	0.000	0.000	0.000*	*********	*********	*********	*********	*********
5	*********	*********	0.123*	0.011*	0.000	0.000	0.000*	*********	*********	*********	*********	*********
6	*********	*********	0.119*	0.007*	0.000	0.000	0.000*	*********	*********	*********	*********	*********
7	*********	*********	0.116*	0.004*	0.000	0.000	0.000*	*********	*********	*********	*********	*********
8	*********	*********	0.112*	0.000	0.000	0.000	0.000*	*********	*********	*********	*********	*********
9	*********	*********	0.108*	0.000*	0.000	0.005	0.000*	*********	*********	*********	*********	*********
10	*********	*********	0.105*	0.000*	0.000	0.012	0.000	*********	*********	*********	*********	*********
11	*********	*********	0.101*	0.000*	0.000	0.000	0.204	*********	*********	*********	*********	*********
12	*********	*********	0.098*	0.000*	0.000	0.000	15.995 1	*********	*********	*********	*********	*********
13	*********	*********	0.094*	0.000*	0.000	0.000	8.793 2	*********	*********	*********	*********	*********
14	*********	*********	0.090*	0.000*	10.130	0.000	1.770	*********	*********	*********	*********	*********
15	*********	*********	0.087*	0.000*	28.052 1	0.000	0.331	*********	*********	*********	*********	*********
16	*********	*********	0.083*	0.000*	17.832 1	0.000	0.056	*********	*********	*********	*********	*********
17	*********	*********	0.080*	0.000*	11.432	0.000	0.012	*********	*********	*********	*********	*********
18	*********	*********	0.076*	0.000*	3.213	0.000	0.000	*********	*********	*********	*********	*********
19	*********	*********	0.072*	0.000*	3.466	0.000	*********	*********	*********	*********	*********	*********
20	*********	*********	0.069*	0.000*	1.195	0.000*	*********	*********	*********	*********	*********	*********
21	*********	*********	0.065*	0.000*	0.000	0.000*	*********	*********	*********	*********	*********	*********
22	*********	*********	0.061*	0.000*	0.000	0.000	*********	*********	*********	*********	*********	*********
23	*********	*********	0.058*	0.000*	0.000	0.000*	*********	*********	*********	*********	*********	*********
24	*********	*********	0.054*	0.000*	0.000	0.000*	*********	*********	*********	*********	*********	*********
25	*********	*********	0.051*	0.000*	0.000	0.000*	*********	*********	*********	*********	*********	*********
26	*********	*********	0.047*	0.000*	0.000	0.000*	*********	*********	*********	*********	*********	*********
27	*********	*********	0.043*	0.000*	0.000	0.000*	*********	*********	*********	*********	*********	*********
28	*********	*********	0.040*	0.000*	0.000	0.000*	*********	*********	*********	*********	*********	*********
29	*********	*********	0.036*	0.000*	0.000	0.000*	*********	*********	*********	*********	*********	*********
30	*********	*********	0.033*	0.000*	0.000	0.000*	*********	*********	*********	*********	*********	*********
31	*********	0.000	0.029*	0.000*	0.000	0.000*	0.000	*********	0.000	*********	*********	0.000
TOTAL	********	********	*********	0.101	75.321	0.016	*********	********	********	********	********	********
MEAN	********	********	********	0.003	2.690	0.001	********	********	********	********	********	********
MAX	0.000	0.000	0.130	0.025	28.052	0.012	15.995	0.000	0.000	0.000	0.000	0.000
MIN	********	********	0.029	0.000	0.000	0.000	0.000	********	********	********	********	********
AC-FT	********	********	*********	0.201	149.397	0.032	*********	********	********	********	********	********

1) Weir capacity exceeded.
2) Weir washout 4-12, flow not measured accurately afterwards.
* Interpolated value.


** DISCHARGE, CFS **
0.00
4.01
8.01
12.02
16.03
20.04
24.04
28.05
OCT
NOV
DEC
JAN

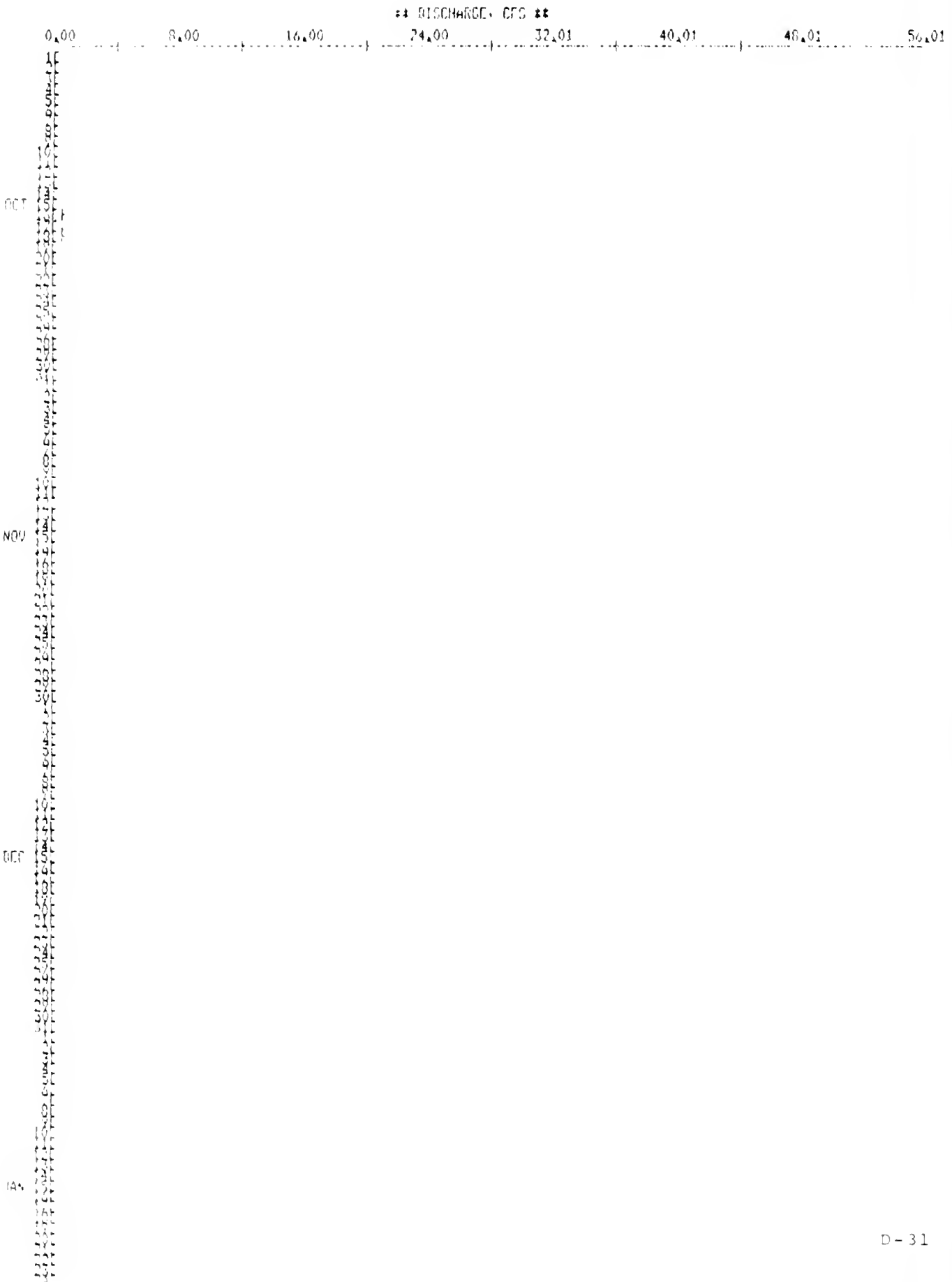

JUN
JUL
AUG
SEP
** DISCHARGE, CFS **
0.00
4.01
8.01
16.04
20.04
24.04
28.05
STOP
Ready

STATION 06330[illegible] SAND COULEE CREEK NEAR CENTERVILLE, MT.
WATER YEAR FROM SEPT 1980 TO OCT 1 1981 T 19N R 04E SEC 13 AAAC LAT [illegible] LONG [illegible]

MEAN DISCHARGE, CFS

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	**********	0.219	0.000	0.000	0.000	0.000	35.166	2.413	49.450*	31.503*	[illegible]	[illegible]
2	**********	0.216	0.000	0.000	0.000	0.000	31.561	2.357	46.062*	[illegible]	[illegible]	[illegible]
3	**********	0.252	0.000	0.000	0.000	0.000	25.364	2.253	48.256*	39.395*	[illegible]	0.004
4	0.097	0.202	0.000	0.000	0.000	0.000	22.812	2.181	47.671*	34.000*	[illegible]	[illegible]
5	0.074	0.202	0.000	0.000	0.000	0.000	22.343	2.191	47.075*	29.204*	[illegible]	[illegible]
6	0.076	0.184	0.000	0.000	0.000	0.000	24.376	2.765	46.479*	28.602*	[illegible]	[illegible]
7	0.068	0.167	0.000	0.000	0.000	0.000	23.412*	3.393	45.884*	28.013*	[illegible]	[illegible]
8	0.060	0.200	0.000	0.000	0.000	0.000	22.447*	4.866	45.288*	27.417*	[illegible]	0.462
9	0.060	0.186	0.000	0.000	0.000	0.000	21.483*	16.462	44.692*	26.821*	[illegible]	[illegible]
10	0.105	0.188	0.000	0.000	0.000	0.000	20.518*	11.432	14.096*	24.226*	[illegible]	[illegible]
11	0.136	0.204	0.000	0.000	0.000	0.000	19.554*	11.194	43.501*	25.630*	[illegible]	0.[illegible]
12	0.150	0.241	0.000	0.000	0.000	0.000	18.589*	15.344	42.905*	25.034*	6.567*	[illegible]
13	0.142	0.093	0.000	0.000	0.000	0.000	17.625*	16.804	42.309*	24.438*	[illegible]	0.[illegible]
14	0.124	0.042	0.000	0.000	0.000	0.000	16.660*	14.430	41.714*	23.843*	[illegible]	0.580
15	0.343	0.035	0.000	0.000	0.000	0.000	15.696*	15.344	41.118*	23.247*	4.780*	0.580
16	0.527	0.058	0.000	0.000	0.000	0.000	14.731*	32.346	40.522*	22.651*	[illegible]	0.580
17	0.908	0.057	0.000	0.000	0.000	0.000	13.767*	51.139	39.927*	22.056*	3.589*	0.580
18	0.740	0.066	0.000	0.000	0.000	0.000	12.802*	51.139	39.331*	21.460*	3.093*	0.556
19	0.451	0.055	0.000	0.000	0.000	0.000	11.838*	51.139	38.735*	20.864*	2.398*	0.556
20	0.316	0.017	0.000	0.000	0.000	0.000	10.873*	51.139	38.140*	20.269*	1.802*	0.556
21	0.261	0.042	0.000	0.000	0.000	0.000	9.909*	56.010 1	37.544*	19.673*	[illegible]	[illegible]
22	0.322	0.005	0.000	0.000	0.000	0.000	8.944*	55.415* 1	36.948*	19.077*	[illegible]	0.587
23	0.293	0.000	0.000	0.000	0.000	0.000	7.980*	54.819* 1	36.352*	18.481*	[illegible]	[illegible]
24	0.278	0.000	0.000	0.000	0.000	0.000	7.015*	54.223* 1	35.757*	[illegible]	[illegible]	0.587
25	0.283	0.000	0.000	0.000	0.000	0.000	6.051*	53.628* 1	35.161*	17.290*	0.856	0.856
26	0.312	0.000	0.000	0.000	0.000	0.124	5.086*	53.032*	34.565*	[illegible]	[illegible]	0.939
27	0.330	0.000	0.000	0.000	0.000	11.095	4.122*	52.436*	33.970*	16.099*	0.763	0.883
28	0.290	0.000	0.000	0.000	0.000	9.487	3.157	51.841*	33.374*	[illegible]	[illegible]	0.790
29	0.264	0.000	0.000	0.000	0.000	20.754	2.685	51.245*	32.778*	14.907*	[illegible]	[illegible]
30	0.245	0.000	0.000	0.000	0.000	32.557	2.606	50.649*	32.183*	14.312*	[illegible]	0.714
31	0.238	0.000	0.000	0.000	0.000	32.681	0.000	50.053*	0.000	13.716*	1.146	0.650
TOTAL	**********	2.884	0.000	0.000	0.000	111.695	459.167	848.697	[illegible]	[illegible]	[illegible]	[illegible]
MEAN	**********	0.096	0.000	0.000	0.000	3.603	15.306	30.603	40.820	25.651	[illegible]	[illegible]
MAX	0.908	0.241	0.000	0.000	0.000	32.557	35.166	56.010	49.450	[illegible]	[illegible]	1.079
MIN	0.060	0.000	0.000	0.000	0.000	0.000	2.606	2.191	32.183	13.716	[illegible]	0.556
AC-FT	**********	5.721	0.000	0.000	0.000	221.543	910.743	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

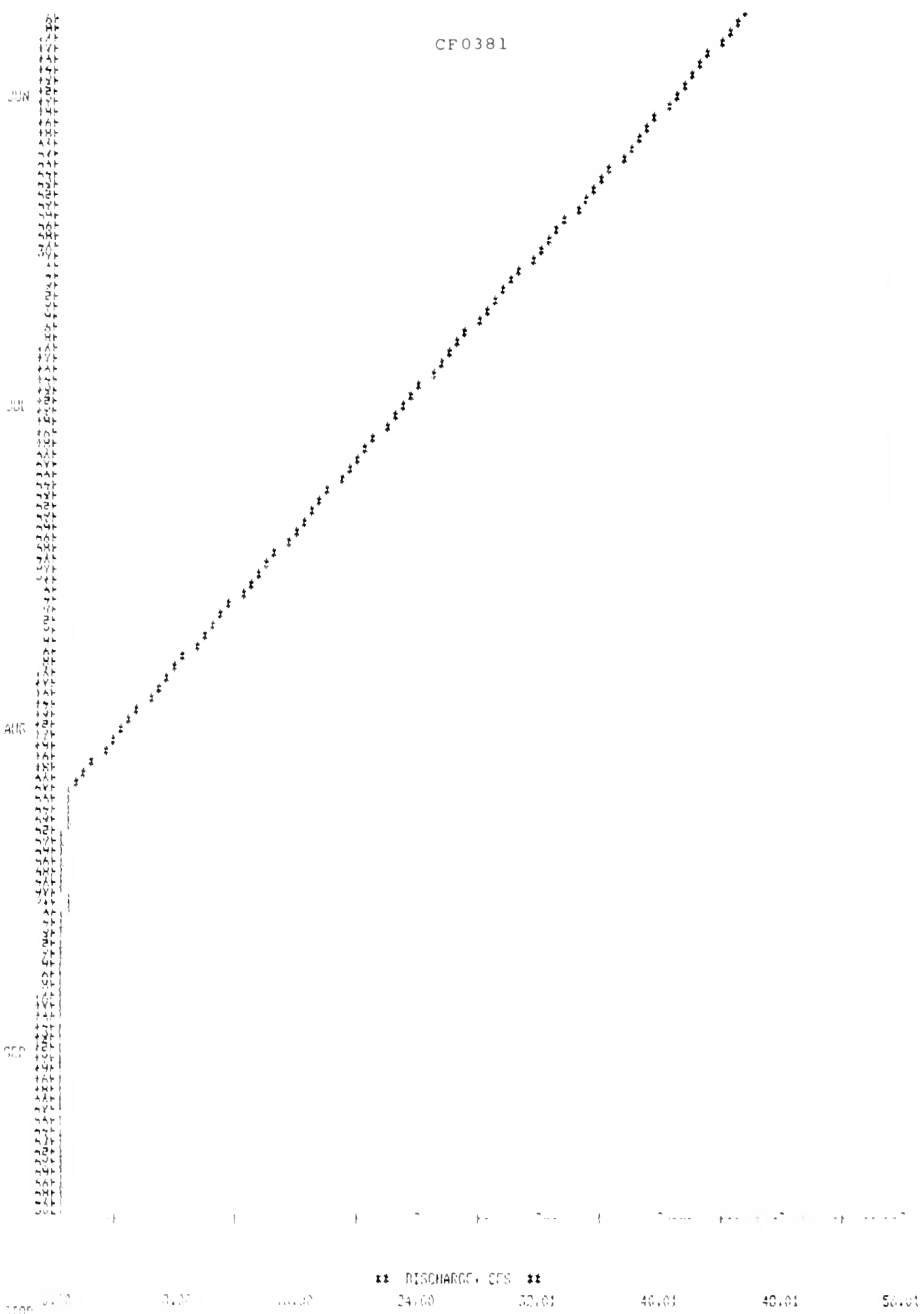
1) Weir capacity exceeded; washout occured 5-21, repaired 8-21.
* Interpolated value.


** DISCHARGE, CFS **
0.00
8.00
16.00
24.00
32.01
40.01
48.01
56.01
OCT
NOV
DEC

FEB

MAR

APR

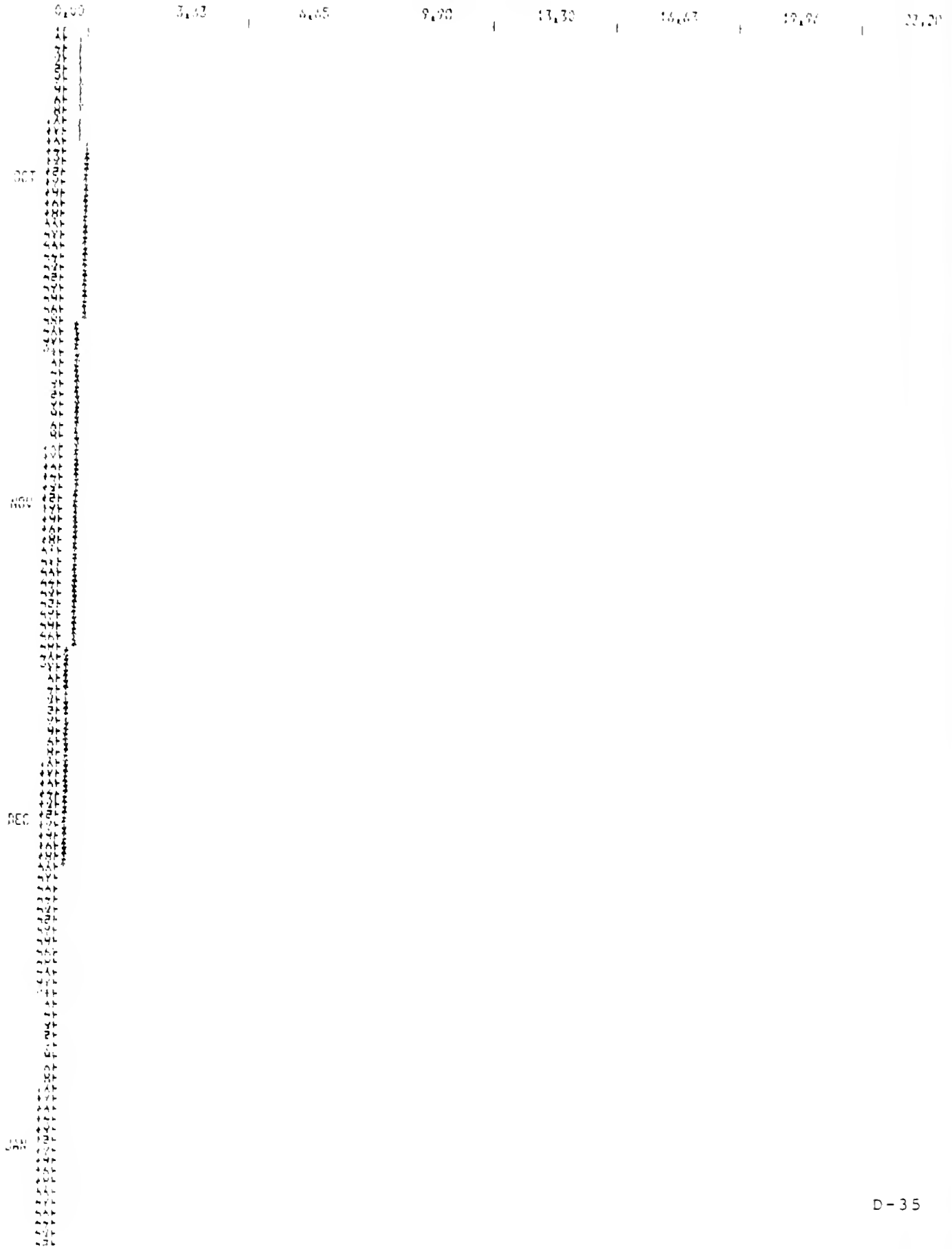

CF0381
JUN
JUL
AUG
SEP
** DISCHARGE, CFS **
24.00
32.01
40.01
48.01
50.01

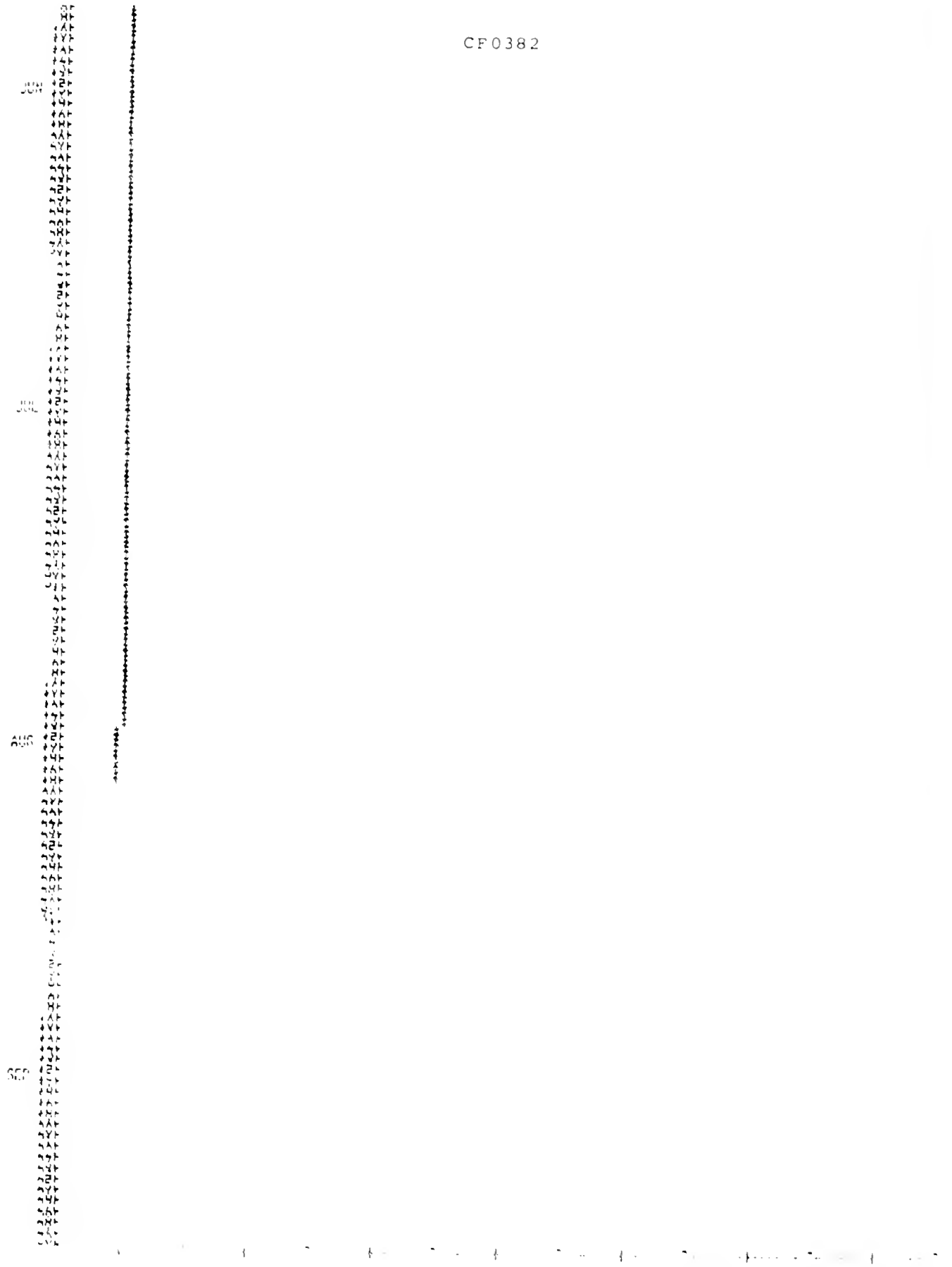
STATION 09380[illegible] SAND GULCH CREEK NEAR CENTERVILLE, UT.
WATER YEAR FROM SEPT 1981 TO OCT 1 1982 [illegible]

MEAN DISCHARGE, CFS

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	0.660	0.600*	0.390*	0.074*	0.000*	0.000*	0.073	1.070*	1.01*[1]	1.05*[1]	1.0**[1]	**********
2	0.660	0.593*	0.380*	0.064*	0.000*	0.000*	0.366	1.04*[1]	1.00*[1]	.*40[1]	.*05[1]	**********
3	0.580	0.566*	0.480	0.053*	0.000*	0.000*	0.120	1.03*[1]	1.00*[1]	1.*3[1]	1.**[1]	**********
4	0.660	0.570*	0.371*	0.042*	0.000*	0.000*	0.134	1.02*[1]	1.00*[1]	.*34[1]	1.**[1]	**********
5	0.580	0.573*	0.361*	0.032*	0.000 [1]	0.000*	0.202	1.01*[1]	1.00*[1]	1.*4[1]	1.**[1]	**********
6	0.572	0.560*	0.350*	0.021*	0.000*	0.000*	0.340	1.00*[1]	1.00*[1]	.*34[1]	.*32[1]	**********
7	0.556	0.559*	0.339*	0.011*	0.000*	0.000*	0.003	1.00*[1]	1.00*[1]	1.*3[1]	1.**[1]	**********
8	0.522	0.552*	0.329*	0.000	0.000*	0.000*	0.000	1.00*[1]	1.00*[1]	1.*3[1]	1.**[1]	**********
9	0.513	0.545*	0.318*	0.000*	0.000*	0.000*	0.000	1.00*[1]	1.00*[1]	1.*2[1]	1.**[1]	**********
10	0.531	0.539*	0.308*	0.000*	0.000*	0.000*	0.438	1.00*[1]	1.00*[1]	1.*2[1]	1.**[1]	**********
11	0.804	0.532*	0.297*	0.000*	0.000*	0.000*	4.524	1.00*[1]	1.00*[1]	1.*2[1]	1.**[1]	**********
12	0.736	0.525*	0.286*	0.000*	0.000*	0.000*	23.203[2]	1.00*[1]	1.00*[1]	1.*2[1]	1.**[1]	**********
13	0.729*	0.518*	0.276*	0.000*	0.000*	0.000*	15.689	1.00*[1]	1.00*[1]	1.*2[1]	1.**[1]	**********
14	0.722*	0.511*	0.265*	0.000*	0.000*	0.000*	5.519	1.00*[1]	1.00*[1]	1.*2[1]	1.**[1]	**********
15	0.716*	0.504*	0.255*	0.000*	0.000*	0.000*	1.905	1.00*[1]	1.00*[1]	1.*2[1]	1.**[1]	**********
16	0.709*	0.490*	0.244*	0.000*	0.000*	0.000*	1.903*	1.00*[1]	1.00*[1]	.*20[1]	.*52[1]	**********
17	0.702*	0.491*	0.233*	0.000*	0.000*	0.000*	1.901*	1.00*[1]	1.00*[1]	1.*1[1]	1.**[1]	**********
18	0.695*	0.484*	0.223*	0.000*	0.000*	0.000*	1.899*	1.00*[1]	.*76[1]	.*18[1]	1.**[1]	**********
19	0.688*	0.477*	0.212*	0.000*	0.000*	0.000*	1.897*	1.00*[1]	1.77*[1]	1.*1[1]	1.**[1]	**********
20	0.681*	0.470*	0.202*	0.000*	0.000*	0.000*	1.895*	1.00*[1]	1.77*[1]	.*10[1]	**********	**********
21	0.675*	0.464*	0.191*	0.000*	0.000*	0.000*	1.893*	1.00*[1]	1.77*[1]	1.*0[1]	**********	**********
22	0.668*	0.457*	0.180*	0.000*	0.000*	0.000	1.891*	1.00*[1]	1.76*[1]	.*07[1]	**********	**********
23	0.661*	0.450*	0.170*	0.000*	0.000*	0.000*	1.889*	1.00*[1]	1.76*[1]	1.*5[1]	**********	**********
24	0.654*	0.443*	0.159*	0.000*	0.000*	0.000*	1.887*	1.00*[1]	1.76*[1]	1.*3[1]	**********	**********
25	0.647*	0.436*	0.149*	0.000*	0.000*	0.000*	1.885*	1.00*[1]	1.76*[1]	1.*1[1]	**********	**********
26	0.641*	0.430*	0.138*	0.000*	0.000*	0.000*	1.883*	1.00*[1]	1.76*[1]	.*09[1]	**********	**********
27	0.634*	0.423*	0.127*	0.000*	0.000*	0.000	1.881*	1.00*[1]	1.75*[1]	1.*7[1]	**********	**********
28	0.627*	0.416*	0.117*	0.000*	0.000*	0.256	1.879*	1.00*[1]	1.75*[1]	1.*5[1]	**********	**********
29	0.620*	0.409*	0.106*	0.000*	0.000	1.770	1.877*	1.00*[1]	1.75*[1]	1.*3[1]	**********	**********
30	0.613*	0.402*	0.095*	0.000*	0.000	1.*37	1.875*	1.00*[1]	1.75*[1]	.*71[1]	**********	**********
31	0.607*	0.000	0.085*	0.000*	0.000	0.622	0.000	1.00*[1]	0.000	1.*8[1]	**********	0.000
TOTAL	19.774	15.032	7.553	0.297	0.000	3.793	81.705	57.114	53.429	53.307	**********	**********
MEAN	0.638	0.501	0.244	0.010	0.000	0.122	2.724	1.842	1.781	1.720	**********	**********
MAX	0.736	0.600	0.396	0.074	0.000	1.770	23.203	1.073	1.080	1.750	1.*87	0.000
MIN	0.513	0.402	0.085	0.000	0.000	0.000	0.000	1.010	1.752	1.600	1.*5[1]	**********
AC-FT	39.221	29.815	14.981	0.589	0.000	7.523	162.040	113.283	105.975	105.733	**********	**********

1) Recorder inoperable 2-6 through 3-21.
2) Weir washout occured 4-12, partial flow measurement only.
* Interpolated value.


** DISCHARGE: CFS **
0.00
3.33
6.65
9.98
13.30
16.63
19.95
23.28
CFS
200
150
100
50



STOP
Ready

APPENDIX E

PROPOSED AMD MITIGATION ALTERNATIVES

The MBMG proposed 5 alternative acid mine drainage treatment measures for field testing to the Montana Department of State Lands in March, 1983. A description of the theory and proposed tests of each alternative are contained in this appendix.

E.1 State-of-the-Art in AMD Control

Lime and limestone treatment of acid mine drainage is a proven mitigation technique (Kim, et al., 1982; Bituminous Coal Research Institute, 1971; Hydrometrics, 1982). While lime ($Ca(OH)_2$) is more effective at neutralization per unit weight than limestone, several factors favor usage of limestone in crushed or pulverized form, including low cost per unit neutralization, local availability, fewer safety problems in handling a less reactive reagent, lower potential for harmful effects on the body of water receiving the effluent and denser sludge. Diebold (1975) found that one-inch crushed limestone fragments provided effective neutralization of iron and copper loads in Montana acid mine drainage at Hughesville, but not of manganese, zinc and cadmium. Even if centralized neutralization facilities are effective, they require significant capital and maintenance investments and are not easily adaptable to treatment of a number of polluting mines over a wide area without a sophisticated collection system, such as is the case at Sand Coulee. In addition, such facilities must be operated continuously, under a variety of discharge and climatic conditions.

Centralized lime neutralization facilities produce large quantities of amorphous sludge which present major handling and disposal problems. Large neutralization facilities are operated successfully, however, in areas where active mining is ongoing, and trained personnel and equipment are available. The lack of mining operations and dispersed nature of AMD sources in the Sand Coulee area are a major impediment to centralized neutralization.

Hydrometrics (1982) list 22 effluent treatment techniques for AMD control at Sand Coulee. They rule out all but three for various reasons: streamflow regulation, evaporation ponds and neutralization facilities. They list 17 mine manipulation techniques, three of which were designated as being potentially applicable: dam and flooding, hydraulic seals and seals using mine backfill. Eight hydrologic system control methods were listed, two of which were deemed potentially applicable: overburden water removal by wells and vegetative evapotranspiration.

Hydrometrics gave a qualitative rating of the potentially applicable methods to 10 acid discharges in the Stockett-Sand Coulee area. The highest rating of any technique was "fair", given to dam and flooding of the AS04 adit (Brown Mine). Most ratings of success were poor, undetermined, no potential or variable. Overburden water removal methods were rated as poor for all sources, due to inadequate information on the aquifers involved and potentially large costs associated with well installation, maintenance, water pumping and piping. Evapotranspirational controls were rated poor or variable for various AMD sources, primarily due to insufficient information on recharge areas and no previous documentation of this technique for AMD control.

The U.S. Bureau of Mines (Kim, et al., 1982) has recently assessed the long-term success of various acid mine drainage treatments. Their recent inspections of wet, dry and hydraulic and/or bulkhead seals constructed over 10 years ago in West Virginia, revealed failures of 5 clay seals and continued discharge of acid water to a receiving stream. They indicated that mine sealing and flooding of 43,000 acres of old coal mines in Pennsylvania which are below the local drainage elevation, began over 30 years ago and that the water in some mine pools is now slightly alkaline. However, they state that in deep mines above the drainage elevation, "flooding is generally ineffective owing to seepage through fractures and the tendency of the water to migrate to other discharge points." The latter situation is the predominate case in the Stockett-Sand Coulee coal field.

The U.S. Bureau of Mines study briefly mentioned that overburden dewatering methods in the eastern U.S. have had limited success but are highly dependent on favorable hydrogeologic conditions. They made no reference to evapotranspirational control methods as a means of reducing infiltration to mines.

Results of this investigation generally support the findings of the previous studies. Mine sealing is one control technique which has been attempted in the Stockett vicinity. In one case, near the Giffen mine, sealing was performed successfully, but within a few months after sealing, a small seep had developed in the center of a nearby tract of agricultural land. Within a year, the seep had developed into a large marshy area discharging a flow reportedly not greatly different than that of the original spring. Because of the unpredictability of the effects of such sealing efforts, a number of local residents are

opposed to its use, as indicated by the results of the resident questionnaire carried out by Hydrometrics (1982).

E.2 Infiltration Control by Intensive Cropping Methods

Planting of water-consumptive crops such as alfalfa, sanfoin and safflower and the use of continuous cropping rotations has been shown to be effective in limiting the amount of infiltration allowed to recharge shallow saline-seep ground-water systems (Miller et al., 1981). It is conceivable that application of such cropping practices could reduce infiltration to mine adits that cause acid discharge. Saline-seep research has demonstrated that alfalfa sends roots to depths of 15 feet or more, utilizing 18 in. of water annually, whereas cereal grains root to only several feet and utilize 7 to 8 in. of water annually. Recropping of cereal grains when soil moisture permits will almost double the evapotranspirational water use over the former 2-year crop-fallow system (Brown and Miller, 1978).

A drawback with this approach is that some of the recharge to ground water occurs in the late winter (during snowmelt) or during spring rains, when most crops are not consuming large amounts of water and when direct evaporation is minimal. The soils on the benches are thin and permeable, so that soil moisture may not be retained long enough for it to be consumed by crops in the summer months. However, in this area intensive cropping will decrease the volume of excess infiltration to some extent, even if it does not eliminate it entirely. Other infiltration control methods, such as draining of leaky upland stock ponds or ephemeral natural potholes, may reduce infiltration substantially and should be considered.

Efforts to reduce infiltration by intensifying agriculture, would have to be monitored via observation wells in the Kootenai aquifer and measurement of AMD discharge for a number of years after implementation, before the degree of their success could be evaluated. Full root development and water use by alfalfa, for example, does not occur until the third year after planting.

Acid discharge sources fed primarily by local recharge areas currently in a crop-fallow rotation are the best candidates for testing this infiltration control method. Such areas include the cultivated benches above AS01, AS02, AS06, AS07, CS01 and CS02.

Effective implementation of cropping system charges for control of dryland saline seep has been shown to require technical assistance to the farmers involved (Dodge et al., in press). Long term adoption of intensive farming practices in the study area must prove to be practical and economical if wholesale reliance on subsidies is to be avoided.

E.3 Horizontal Wells and Connector Wells

Installation and pumping of standard vertical wells to dewater the Kootenai aquifer, which is contributing leakage to abandoned mines, is a potential mitigation measure. However, the continued costs of pumping and maintenance appear to make this an undesirable and expensive alternative.

It is possible to take advantage of, or create, favorable differences in hydraulic head within wells, to gravity drain water from one aquifer to another or to the surface. The two well designs possible for use in dewatering the Kootenai aquifer are the connector

well and the horizontal well. The connector well would drain ground water from the basal Kootenai sandstone aquifer to the Madison group limestone which has a lower head, thereby preventing that water from draining into old mines and becoming acidized. The horizontal well would be drilled from a coulee into the basal Kootenai sandstone, just upgradient from old mine workings, and allow ground water to drain to the coulee before it leaks into the mines.

Connector wells have been used to dewater shallow aquifers in mining applications. A recent U.S. Geological Survey publication (Bush, 1983) describes the successful test of one connector well to recharge 50 gpm under gravity flow from a shallow sand aquifer to the underlying Floridan Limestone aquifer in central Florida. There is limited evidence to suggest that some domestic wells in the Stockett-Sand Coulee area may act as connector wells. A drillers log on a private well in T. 19 N., R. 4 E., sec. 23, indicates that ground water was encountered in the basal Kootenai sandstone, but that drilling continued 356 feet into the Madison limestone where a cavity was encountered. The total well depth was 586 feet, 71 feet below the cavity level and the well was uncased below 20 feet. The reported static water level was 515 feet below ground surface, just at the level at the bottom of the cavity. Ground water from the Kootenai aquifer may flow down the well bore to the level of the cavity in the Madison. The instances of contaminated Madison wells mentioned in section 2.2.5.1 also illustrates the connector well principle. If applied to the AMD problem, the connector wells would inject fresh Kootenai water into the Madison group limestone.

Horizontal drainage wells have been most frequently used in

dewatering of mining headwalls and highway road cuts. In the Stockett-Sand Coulee area, horizontal wells could be drilled into the sides of coulees upgradient from existing AMD sources as a test of this technique. Their obvious advantage is the use of gravity drainage and the elimination of long-term pumpage requirements. Secondarily, the water removed through drainage would be typical alkaline Kootenai water and with a minimum of conveyance would be available for dilution of other AMD water in the receiving stream.

Favorable sites for horizontal well tests include several acid springs and mine discharges near Sand Coulee such as AS01, AS04, AS09, CS01 and CS02. The configurations of these coulees and predominantly local recharge sources create apparently favorable conditions for intercepting a sizeable portion of the ground-water flow field reaching the old mine workings.

The drilling distances would be variable, depending on the test site chosen and the quantities of water intercepted as the drilling progresses. It is estimated that a 500-1000 ft. hole would be attempted initially. The yield of a horizontal drainage well in the basal Kootenai sandstone is problematical, very much dependent on the quantity of saturated fractures encountered.

Vertical test wells would be drilled on the benches above these adits to the Morrison coal bed along the projected axis of the horizontal well. This will help confirm the extent of the old mine workings and provide elevation control on the basal Kootenai sandstone prior to drilling the horizontal wells.

The effectiveness of the horizontal wells in AMD control would be determined by measuring the discharge from the two adits with flumes or

weirs fitted with continuous recorders, both before and after operation of the drainage wells. The drainage well discharge would be measured continuously with recording flowmeters or flumes. Both adit and drainage well disharge would be sampled for water quality analyses during the flow tests.

E.4 Subsurface Injection of AMD

A potential AMD disposal and neutralization method may be gravity injection into the Madison limestone. The effectiveness and impacts of injection could be assessed with controlled field tests. The objectives of the tests would be to determine the effectiveness of AMD neutralization, porosity--permeability changes due to injection, extent of metal precipitation, and water quality impacts of AMD injection on the Madison aquifer.

Acid mine drainage leakage into the Madison aquifer is already occurring throughout the Stockett-Sand Coulee area in an uncontrolled fashion. There are several cases of Madison ground-water contamination reported by landowners and at least four additional suspected cases based on MBMG water quality data. AMD disharge in Sand Coulee, Number Five Coulee, Cottonwood Creek and Straight Creek is known to be lost to subsurface seepage, contaminating alluvial ground waters and probably the Madison as well. The results of controlled AMD injection tests would indicate whether such a procedure is preferable to uncontrolled leakage to several aquifers along the entire drainage network.

However, there is reason to question the applicability of such an injection program. As acid mine water is discharged into partially saturated zones of cavernous porosity in the Madison, several processes

will take place concurrently. If undiluted acid water comes in direct contact with limestone in the unsaturated portion of the Madison, it will tend to dissolve carbonates and may enhance porosity. As the pH rises above 4.5, both iron and aluminum will rapidly precipitate from solution as insoluble, amorphous hydroxides. As it reaches the saturated portion of the Madison, it may have little or no remaining acidity; what acidity remains will be buffered by the alkalinity of the Madison water, causing complete precipitation of the metal load down to the solubility of controlling metal hydroxide or carbonate species.

The major obstacle to the successful operation of such an injection well system would probably be the ability of the aquifer and well to resist becoming clogged with metal hydroxide precipitation products. Mines in the Sand Coulee area, those of poorest quality in the region, typically range from 600-1600 mg/L total dissolved metals, primarily iron and aluminum with much lesser quantities (<50 mg/L Zn, <10 mg/L Ni, Cu, Mo) of other metals. Assuming an average annual discharge of 40 gpm (2.5 liters per second (l/s)) for a hypothetical spring of typical water quality and metal load (TDS = 5000 mg/L; metals = 1.1 grams/L), and assuming a mean density of 3.0 g/cc for the metal precipitate (gibbsite - 2.4; ferric hydroxide - 3.3-4.3, depending on hydration), a total volume of 1024 ft^3/year will precipitate from solution in the subsurface if the total discharge were to be injected into the Madison. Assuming a void ratio of 100 percent in this precipitate, approximately 1766 ft^3/year would precipitate from injection water of just one spring. Such volumes could potentially clog even a large zone of cavernous porosity in the Madison over the period of a few years.

However, there are some factors which would support the feasibil-

ity of injection. First of all, the water would most likely be injected into the upper Madison which is partially unsaturated, and before it reaches the water table it may dissolve a significant volume of carbonates due to the water's high acidity, enhancing porosity and permeability. Secondly, our results indicate that acid streamflow is probably currently leaking into the underlying Madison in the Sand Coulee-Stockett area. Therefore, the injection concept may prove practical, provided that zones of cavernous porosity are present in the Madison to accommodate the anticipated metal load.

Certainly, however, the water quality impacts of such injection would have to be predicted and evaluated. Acid water injected into the aquifer would become neutralized with respect to metals and acidity. The Madison aquifer may, however, be degraded by the higher sulfate levels (2000-8000 mg/L) in the acid water, or by an increase in Ca^{2+} and Mg^{2+} concentrations due to carbonate and dolomite dissolution.

Many Stockett-Sand Coulee residents have abandoned alluvial wells for deeper Madison aquifer wells. Any acid water injection proposal would have to be sanctioned by residents and carefully monitored to determine overall impacts. We have proposed one possible approach to conducting controlled field tests and evaluation of the injection technique.

Initial well drilling, logging and testing would be conducted to locate a favorable site. The vertical gradient must be downward, and there should be some initial solution or cavernous permeability in the upper unsaturated Madison group limestone.

An initial 10-day injection test would be run. Following a favorable evaluation of the first test, a second 100-day test would be

conducted. Water quality analyses of the observation wells, injection well and mine discharge would be made three or more times throughout the tests. Field pH, S.C. and alkalinity measurements would be made frequently. Continuous water level data would be collected throughout the test periods. The nearest private Madison well would be sampled before and after the test periods.

Following the tests, geophysical logs would be run again on the injection well and observation well changes in porosity and permeability caused by metal hydroxide deposition and carbonate dissolution. Aquifer pumping tests or slug tests would be re-run to determine permeability changes. Two new wells would be drilled to determine the extent of metal deposition and obtain samples.

The results of field sampling would be used as input to hydrochemical modeling of the injection test. Analytical calculations and computer modeling would be employed to estimate the mechanisms and rate of acid neutralization and metal precipitation over time. The extent of porosity, permeability and water quality effects on the Madison aquifer would be evaluated. Recommendations regarding the long-term hydrogeologic feasibility and impacts of AMD injection to the Madison Group rocks would be made.

E.5 Flyash Neutralization

Flyash residue from coal-fired electric power plants is rich in calcium and has been tested and found to be effective in neutralizing pyrite induced acidity. Sonderegger and Donovan (1982) conducted acid titration and batch leach laboratory experiments with various mixtures of flyash and pyrite mine tailings and found that flyash has both

short-term and long-term buffering capacity. A one to ten, flyash to tailings mixture, was estimated to maintain a buffering capacity exceeding 100 years. Iron mobility in column leach tests with flyash was reduced by up to three orders of magnitude.

It is believed that small volumes of acid mine drainage water could be effectively neutralized by short-term retention and mixing with flyash in a small pit. An investigation would be needed to test the effectiveness and maintenance requirements of small flyash pits as a means to neutralize the numerous small acid water discharges in the Stockett-Sand Coulee area.

Pits of about 200 ft^3 in size would be excavated and filled with flyash. Acid inflows would be injected through the bottom of pits, where neutralization occurs prior to being discharged from the top of the downstream side of the pit. Water quality sampling and field testing of pH, S.C. and alkalinity of inflows and outflows would be done to document the rate of neutralization, bulk neturalization capacity of the flyash in the pit and affects on overall water chemistry and metals concentrations. The pit would be profiled afterwards, and maintenance and operation feasibility assessed.

E.6 Kootenai Water Neutralization

A simple and possibly effective AMD neutralization technique would be to mix alkaline ground water from the Kootenai aquifer with small volumes of acid mine drainage water. The mixing would occur in a pit where metals would be allowed to precipitate prior to discharge of the effluent.

Typical ground water from the lower Kootenai formation has an

alkalinity of 200 to 350 mg/l as $CaCO_3$. Assuming a mix of 2500 mg/l (as $CaCO_3$) acid mine water, a 10:1 volumetric ratio of Kootenai to AMD water is required theoretically to achieve neutralization.

A several month test would be conducted to evaluate the effectiveness and field procedures associated with utilization of Kootenai ground water in neutralizing acid mine drainage in the Sand Coulee area.

Water quality samples and field pH, S.C. and alkalinity data would be collected at inflows and outflows to document the effectiveness of the technique.

The flyash and Kootenai ground-water neutralization experiments would be conducted with the purpose of determining the minimal field installation required for non-mechanical but effective treatment of the numerous small and ephemeral acid seeps in the study area. Such an alternative could be adopted by individual residents at low cost to assist regional AMD clean up efforts.

E.7 Treatments in Combination

There will probably never be a single mitigation technique feasible for controlling all acid mine drainages. Once implementation and testing of the previously discussed techniques on an individual basis is completed, various combinations may enhance AMD control.

If the head and permeability characteristics of the basal Kootenai sandstone aquifer prove conducive for horizontal wells, this technique could be combined with mine flooding and bulkheading. The two treatments could complement each other. The horizontal well will provide a hydraulic pressure release mechanism, maintaining hydrodynamic equilib-

rium and helping prevent unplanned seepage. The flooding will slow acid producing reactions in the old mines and may increase head in the overlying sandstone, thereby improving yields from the horizontal well at the expense of mine flow. The discharge of alkaline ground water from a horizontal well may provide an opportunity to neutralize the remaining acid flow in a pit below the source as indicated in the previous section.

Reductions in acid mine baseflows and total volume from intensive farming methods in recharge areas may allow installation of retention ponds or neturalization pits (using flyash or limestone) to treat the remaining acid flow. Mine flooding and bulkheading could be combined with injection of surplus water to a deeper receiving zone such as the Madison group limestone. A closed system overflow pipe could siphon surplus mine pool water in a relatively unoxygenated state to a deeper receiving aquifer. If acid-forming reactions could be minimized in the mine and rapid injection of ground-water recharge slugs accomplished, the injection water may be of better quality than typical AMD water. Mine pool water injected in this manner may result in water quality impacts to the Madison aquifer less than those currently being experienced.